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Economical Engineering Design.

The design of iron and steel construction, and indeed construction in other materials as well, has been the subject of so much study and comment that it seems at first sight eminently superfluous to give it much further consideration, but that is in reality a superficial view of the matter. With every progress made in engineering design there is not only improvement in that design, but a greatly increased demand for still further improvements. Every engineering structure serves a purpose which is no sooner fulfilled than a still wider purpose is to be served by the next design. While these observations are true in general of every line of human activity, they have special force in connection with the extraordinarily rapid development of all engineering work during the past fifty years.

Economical engineering design means much more than the supplying of suitable materials in properly shaped and dimensioned members to meet well-defined stresses subject to more or less accurate computation. As important as is this part of the field of engineering design, there are other matters of at least equal importance and in some respects of far greater importance. The highest purpose of engineering design is the creation of structures or machines to accomplish certain results with the greatest efficiency, which includes the highest degree of true economy. This does not mean either the lowest first cost or the least possible quantity of material or, finally, the most precise or accurate adaptation of materials to meet those particular stresses which are recognized in computations.

It must always be kept prominently in mind that the total cost of the finished work is distributed over what may be called mill products, such as bars, shapes, plates and other similar materials, the shop costs or fabrication, transportation and erection. These four are the main or great elements of cost, each of which must have just as much weight in engineering design as the magnitude of stresses in the stress sheet. No engineer discharges his professional duty in the fullest and best sense of the term without being governed continually by those four elements of cost. As a matter of fact, in every efficiently conducted engineering office it is the purpose to serve the interests of transportation and erection of the fabricated members of a structure as well as those of a purely scientific character.

The capacities of every structural shop for various classes of work control largely the sizes and character of the structural members designed to be manufactured in it. Manifestly the cost of manufacture of a plate girder of such depth and length as will prevent facility of handling in the shop will be increased, and it is bad engineering as well as bad business to design such members where it is practicable to substitute a more economical member. Similarly, if convenient transportation facilities are exceeded, the total cost of the structure will also be enhanced and such a defect is just as much bad engineering design as to provide less area of cross-section in a detail of the structure than is required by the specifications to meet the stress which it carries.

The problem of economical erection has been most carefully studied by engineers engaged in bridge building since that line of engineering work was first begun. Celerity and economy are the two main ends to be attained. Other things being equal a 500-ft. span, which can be coupled and made safe within three or four days is certainly a better design of structure from a purely engineering point of view than one which will require five or six days, and in that observation lies the keynote of this phase of engineering design. Quick and economical erection does not mean impairment of excellence. The great improvements in field work at the present time, by which such extraordinary records of erection are reached as those known at present, have carried with them a far higher degree of excellence than was ever imagined twenty-five or thirty years ago. Obviously power field tools are responsible for much of this improved work, but that simply means an efficient adaptation of means to an end which probably has more to do with highly successful results in field operations than any other agency.

The four main elements of economic engineering design named are largely of an executive or administrative character, and young engineers especially are apt to overlook their importance. Facility or skill in executive or administrative work comes from actual experience or the doing of things, but in spite of that fact there is a great deal of what may be called engineering science mixed with it. Or, to put it differently, the highest type of engineering judgment in these administrative matters is tempered with a thorough scientific knowledge of the technical things involved. There is no higher or more effective field for the play of the scientific or technical training of an engineer than in those elements of every engineering work which correspond to the first cost of materials, fabrication, transportation and erection of iron and steel structural work. There will be a much more direct and efficient adaptation of means to an end, i. e., a greater economy will be attained, when the judgment is guided by a thorough understanding of every influence or agent affecting the results desired to be reached. And this is no less true in economical engineering design than in the broader administration of the more general affairs of the engineer. Economical engineering design means the exercise of professional or technical skill just as actively and effectively in the shop and in the field as in the office.

Electricity in Construction Work.

One of the interesting observations made in the preparation of this number of The Engineering Record was the marked increase in the use of electrically-driven equipment on construction work that has been taking place lately. This field has been neglected by makers of electrical apparatus because it is a relatively small one and hard to cultivate, and consequently they have missed making some sales at very satisfactory figures. The man who buys equipment for such work generally has his office in a little wooden coop far away from the customary paths of the salesman, and when the latter visits the office the superintendent is usually out on the job and hard to find. When found he is absolutely impervious to frontal, side or rear attacks by the usual arguments of the salesman, who is apt to consider the man something of an ignoramus because he manifestly neither knows nor cares very much about load factors or hysteresis. He is also written down as a rank crank because he demands deliveries right away, and the fact that he is perfectly willing to pay a special price to secure such a delivery is probably not brought out in the conversation. As a result of these conditions the introduction of electrically-operated equipment on such work was very slow for a number of years.

The first important contract where electricity was employed extensively was probably the construction of the Brooklyn anchorage of the Manhattan bridge by the Kosmos Engineering Co. Here the pile-driving, hoisting, haulage, concrete mixing, pumping and lighting were done by electrically-operated equipment, as described in detail in this journal on Aug. 26, 1905. The company had a choice in this case of installing a central boiler plant and using steam-driven equipment or of buying current from the local central station and using electrical apparatus. It chose the latter, engaged an electrical engineer to install and manage the plant and saved a tidy sum by doing so. The conditions were particularly favorable for electricity in this case, but no more favorable than they are in the construction of large buildings or similarly concentrated operations in a city where current is available in every street. The time has come when electricity should be used on all such work for hoisting, running air compressors and like purposes. It is already used for lighting, and as soon as the electrical people wake up to the importance of this field it will be employed for other purposes. A number of prominent contractors are now using electricity almost exclusively, but their number is trifling compared with those who will do so as soon as the subject is presented to them properly. It is useless to argue with these people in the way employed in introducing motors in shops, for their viewpoint is wholly different. Their one great aim is to make time. The cost of a few motors is nothing in comparison with their weekly pay-roll, and while they are just as keen as other people in saving money they know perfectly well that money must often be spent in order to save larger sums.

There are other aspects of the use of electricity in construction work that are equally interesting. In tunneling, for example, motors are gradually finding application, and this journal believes that the contractors in this field will shortly become far better acquainted with the usefulness of electricity than they are to-day. There are conditions which may make an electric central station furnishing current to widely separated motor-driven compressors a more satisfactory equipment than a central steam-driven air compressor plant with long lines of air mains. It is also possible that an electric station may be a better central plant on the construction of a large masonry dam than the installations now employed. It is manifest that electric motor cars for hauling dump cars deserve careful consideration for work in some localities, and other possible applications of electricity will occur to those who are acquainted with both construction methods and electrical equipment.

There is one thing that must not be forgotten, however, in any plans for installing electrical apparatus, and this is the fact that construction work is very hard on all machinery. The steam-driven apparatus of to-day is admirable in its adaptation to this service. It represents years of evolution spurred by severe competition, and any attempts to ignore or ridicule it are bound to react on those making them. Such machinery will always have a great field of usefulness, and all that it is safe to do is to substitute a motor for a cylinder on apparatus which will be used where electricity offers greater advantages as an operating agent than steam or compressed air. Attempts to do more than this are very hazardous, and it is safe to say that the best results will be attained when the designers familiar with the standard plant now constructed co-operate with the designers of electric motors. In this way only will it be possible to obtain apparatus which will be as reliable in all its features as that now used with steam and compressed air.

The Opportunity for Motor Trucks.

The figures relating to the cost of haulage of agricultural products which were published last week in this journal are of peculiar interest as bearing upon improved methods of traction. The aggregate cost of haulage from farms can hardly be estimated with any precision, but from the data given on a few products of relatively high value the total must be far in excess of $100,000,000 annually. Even more striking is the relatively high percentage cost of this primary haulage. Averaging over 5 per cent. of the valuation for selected products, it would in the average probably run to 6 per cent. or more. An analysis of the distribution of charges on agricultural products between the producer and consumer would be of profound and startling interest. Nothing would more strikingly show the artificial nature of our commercial operations and the enormous proportion of gain that falls to the lot of intermediaries. The middleman has a legitimate function as a distributor, but most things are levied upon by a long series of aggressive beneficiaries who get most of the gain *en route*. The transportation problem is serious in every large country and the charges are necessarily somewhat heavy, yet through the growth of a purely artificial system, these charges have become a prodigious element of cost, to an extent oftentimes absolutely needless in the general economy of production, and representing little better than plain loot secured by improper monopolies. We are not here concerned with these larger matters, however, so much as with the losses that are incurred in primary transportation—that from the point of production to the consumer or to the first necessary intermediary.

The figures which were published show that the primary haul on the average rises to eight or ten miles, and that its cost amounts on the average to approximately one cent per mile per 100 lb. or 20 cents per ton-mile. High as are railway charges in some bedeviled portions of our country, these primary charges are evidently such as imperatively demand attention. Something has already been done in the way of reducing them by the building of light electric roads. These answer well in the more thickly settled sections of the country. The very places where the hauls are longest are those where even light electric roads will not pay for lack of regular traffic, so that other means of relief must be sought. The evolution of the motor-truck seems about the most promising direction in which to look for relief. Wherever there are fairly level and good roads a motor-truck can not only carry freight at a total cost including repairs and depreciation far below that just cited, but it can carry it at a speed so much greater than is possible with animal traction, that the saving in labor becomes a very important feature of the economic situation. A motor-truck capable of carrying a ton and of moderate cost and power is yet able to make at least double the speed of which horses are capable on similar work. If, as is generally the case in agricultural operations, the haulage is an occasional matter, the saving from motor-trucks is increased, since the charges against them when idle are relatively small. The first cost is, of course, a considerable item. It must not be compared with ordinary automobile costs, however, because it can be and will be brought down more rapidly than the costs on a pleasure vehicle, and because the item of depreciation is comparatively small.

No one can at the present time say what the depreciation of an automobile really is, both because of the short time that motor vehicles have been in use and especially because depreciation due to change in fashion entirely outweighs physical depreciation at the present time. Barring serious accidents, which are mostly due to reckless speed, a well-made chassis ought to last, with moderate repairs and renewals, certainly ten years. The tire question, so serious in large cars, is far less important in motor-trucks owing to the use of solid tires, and the low speed is another favoring item in the consideration of life. Then, too, in farm haulage there is a proper field for co-operative action, since few single farms are large enough to keep a motor-truck worked to anything like its economical capacity. Merely for primary haulage, in place of that now done by animals, the motor-truck is certainly going to find a place, and that before long. It has an even more important function in lengthening the economic radius of primary haulage, thereby dodging some of the intermediaries; or bringing them into competition. With an available speed of eight or ten miles an hour the feasible radius of haulage is more than doubled, so that around a city, for example, more than four times the present territory becomes available for market farming, which is the most profiable kind of agriculture when the long string of greedy intermediaries is reduced to a reasonable extent. The motor-truck, with its space-covering advantages, would amply justify itself as a means of simplifying the distribution of farm products, even if it could do nothing in the way of reducing actual haulage costs. In fact, it seems well fitted to do both, and thus it possesses a double usefulness. In view of these possibilities the improvement of roads becomes almost a matter of self-preservation in rural communities, and the future main roads all over the country should be built with the needs of motor cars in view. If good for these it will be good for all purposes.

The Successful Contracting Organization.

It is very easy for anybody who is not acquainted with the difficulties of a business to tell how it should be run; it is so easy to do so, in fact, that The Engineering Record does not propose to waste its time in such a simple matter. There are a few features connected with a number of successful contracting organizations, however, which it is appropriate to mention in this number, devoted particularly to construction affairs. In the first place it is rather noticeable that the contracting organizations which are now forging ahead as builders of great works are generally marked by the development of two departments which were rarely considered of much importance formerly, one of them devoted to engineering and the other to financial affairs. Twenty-five years ago the leading contractors were generally men who excelled in the handling of skilled and unskilled labor, and what little mechanical equipment they employed was of a class familiar to men who were readily picked up in the larger cities. The engineering work was all done by the engineers of the parties for whom the work was being built, and as there was little plant to buy and few men drawing high wages to provide for, the financial administration of affairs was easily done with the assistance of friendly bankers. All this primitive condition has disappeared in some kinds of work. Very often payment is now made in securities or warrants of one sort or another, so that the profit or loss on a contract may depend largely on the shrewdness with which the monetary affairs of the contractor are handled. The plant required often entails on large work an expenditure of very large amount, and the selection and maintenance of it is a problem requiring the most careful study. Only a short time ago a contractor informed this journal that he had been obliged to charge up the greater part of $150,000 spent on unsatisfactory plant for a certain undertaking to his willingness to back an untried method of working. Under such circumstances it is manifest that the engineering branch of a contractor's organization must be a good one, a fact that is now recognized by a good many progressive contractors. It may be questioned, however, whether the value of good engineering services in such an organization is yet appreciated at anywhere near their true worth.

With the growth of the contractor's organization to include other departments than those engaged in the direct supervision of the workmen, has come a necessity for team work which is by no means properly estimated. There are a number of large contracting organizations which use good equipment and pay fair wages and salaries, but are hotbeds of dissatisfaction. It is bad enough to have the engineering staff engaged in the design and superintendence of an undertaking broken up by internal disturbances, but such a condition is fatal to successful contracting work. Consequently the selection of men, particularly the technical men, for such an undertaking, and their treatment after their services are secured are matters worth plenty of hard thought.

It was of course perfectly true that when a contractor's organization included nobody but workmen and clerks, available everywhere, it was considered enough to see that the men were comfortably housed and well fed. It has long been known that good work could not be secured except when these conditions were fulfilled and very few contractors have a poor reputation in this respect. Something more is needed, however, in dealing with a technical staff, largely recruited from the ranks of technical college graduates. The difference in the abilities of such men is far greater than with skilled workmen; some of them are capable of rapid advancement and others have made a mistake in selecting engineering as a career. Consequently with the increased development of the organization toward more specialized assistants has come a need of greater care in picking the men, as it is among these employes in the higher positions that dissatisfaction, when it occurs, will cost the contractor most money. The more responsibility put on a man, the greater the trouble when he fails to discharge his duties properly.

There are a few contractors at the present time, men of the broadest gauge, who have developed this idea to its utmost. They do not engage in small work and consequently their best men are not obliged to fritter away their time on details. They are constantly looking for big men who have really done things which, to be successful, require executive ability and technical knowledge. These contractors engage such men whenever they are certain that they will be useful in a great organization. Having secured their services on terms which make them feel themselves part and parcel of the organization, the contractors then proceed to get contracts which such men are particularly well qualified to handle. In other words they capitalize the ability of really able men, having confidence that a few thousand dollars spent in salaries for them while they have little to do, will be more than repaid by the profits on contracts they can manage when secured.

It is becoming very apparent that it is a pretty risky thing to take a big contract and then hunt for men able to handle it. While it is the easiest thing in the world to find men who have the technical knowledge necessary to solve the strictly engineering problems that may arise in such work, it is very hard to find men who possess, along with that knowledge, the ability to bring together and manage an organization which is efficient and harmonious. Team work is essential in business affairs; there are many men having a high position in the engineering world who would be entirely out of place in a great organization on account of their inability to make the concessions and to do the occasional overtime work which are required in a large staff. Perhaps this is the reason, or one of the reasons, that a good many men whose technical ability they themselves acknowledge is by no means of the highest grade are able to accomplish so much more good work than the men able to solve the most difficult engineering problems. It is this fact, also, which makes the problem of securing men for the responsible places in a large contracting staff so very difficult, for it is running a great risk to place much responsibility on anybody who is unwilling to take part in team work, but insists on too much individuality.

Another Upheaval in Panama Canal Affairs.

It has long been known that the Isthmus of Panama was subject to seismic disturbance, but it is beginning to look as though its tremblors are insignificant compared with the frequent upheavals of the Canal Commission and the plans for carrying on the digging of the ditch. There have been enough of these disturbances in the last five years to wreck completely any business venture, yet those people who criticized the defective administration of affairs have been called all manner of hard names, from enemies to their country's welfare to ignoramuses and cowards. It has been rather difficult lately to discover the nature of the troubles, because the Isthmian Canal Commission has been apparently ignored by the President and canal affairs have been handled directly from the White House. The only remedy for the growing hopelessness of canal affairs and the discouragement of the men on the Isthmus lies in the possibility of some man of broad-gauge executive ability and technical judgment being able to secure the confidence of the President. What evil influence has persistently induced the latter to listen to the counsel of men with hobbies instead of those without such prejudices is a conundrum that puzzles a good many people. Mr. Roosevelt's remarkable ability in dealing with men has not failed him in dealing with the problems of great engineering work through any other reason than his inability to put enough of his own time on canal affairs to discover for himself the source of the trouble. Had he been able to give more of his attention to the work on the Isthmus and its problems, he would long ago have discovered that he was trying to fit round men into square holes, engaging surgeons for physicians' work, and letting men's high reputation for certain specialties convince him they were safe counsellors on subjects their previous experience manifestly prevented them from viewing in an unbiassed manner. The Engineering Record has the highest admiration for the President's great abilities and its position in opposition to his plans for the canal has been taken with great regret and only from a sense of public duty.

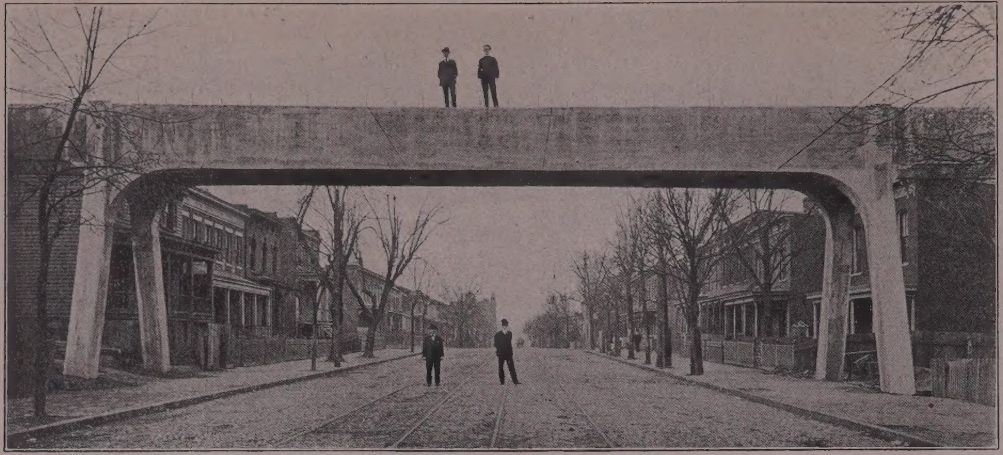
These plain statements are made because this journal is now able to endorse heartily the latest action of Mr. Roosevelt in canal affairs. The greatest single need that he has had for a long time was a technical adviser in whom his temperament would enable him to place absolute confidence. In Major G. W. Goethals, Corps of Engineers, appointed chief engineer on Feb. 26, he has at last secured a man without prejudice who will probably answer this need. The Engineering Record has but a slight acquaintance personally with this officer, but it knows his record thoroughly and congratulates the country on his appointment. Among those who have come into contact with him in business and engineering affairs he is known as a fair-minded man whose talent for getting at the bottom of affairs is as exceptional as his executive ability. He has never been a lobbyist or an aspirant for social honors; he has done a lot of things well and his official reports have been frank and outspoken in unfavorable as well as favorable criticism of the projects of those in positions above him. Along with all these qualities he is extremely reticent and has a strong prejudice against the spotlight of publicity being turned his way. The Engineering Record is delighted that he has been appointed, and trusts that along with his appointment he will receive enough authority and assistance to make a thorough investigation of the conditions at the Isthmus.

The action of the President in rejecting all bids for the construction of the canal is manifestly a wise one, in view of the reorganization of the Commission which the appointment to it of Major Goethals, Major Gaillard, Major Sibert and Senator Blackburn indicates as imminent. It is very likely that construction can be done by contract on the Isthmus without recourse to a blanket agreement in which a large part of the profits will go to bankers. Possibly the President has in mind the division of profits which occurred in connection with the construction of the first New York subway, and believes that the Government, by financing the contractors, can save to the public treasury a considerable sum that would otherwise be paid to bankers. However that may be, it is manifestly right to all concerned to defer making any contracts until there has been a thorough detailed investigation of the conditions on the Isthmus at the present time. Such an investigation can be made by Major Goethals without much delay, provided he is given the full authority needed for the purpose; the employees of the Commission on the Isthmus will find that the new chief engineer will demand implicit obedience to his orders and absolute frankness in their reports, but if these conditions are fulfilled their new superior will be an ideal chief. Up to the present time they have had no man as their head who was familiar with Government routine, and a good many of their little inconveniences have been due to this fact. The appointment of an engineer officer distinguished alike for technical knowledge and executive ability should be welcomed by them. This statement is no reflection on Messrs. Wallace and Stevens, whose previous experience could not possibly prevent their restlessness under regulations which Government officials accept as matters of course.

The Builder's Skilled Army.

The construction of a large office building is an undertaking which demonstrates very well the importance of the work of the general building contractor, and special attention is called on this account to the description elsewhere in this issue of the erection of the Trinity and United States Realty Buildings in New York. Two thousand men make a pretty large force for an industrial establishment laid out with careful attention to facilitating their work. Such a force of men, almost wholly skilled mechanics, are now at work on these buildings, and it does not require much thought to understand that the efficiency of this force is tremendously increased by the same attention given to their working conditions which is paid to shop arrangements. The great success of the leading general contractors who handle such construction is to be attributed to the skill with which all this detail administration is worked out.

In the article which is printed on page 302 it is pointed out that only a trifling amount of materials can be stored at the site of the buildings, and consequently no small part of the contractor's work has been to supervise the preparation of the materials in the steel mills, quarries and shops and to watch its transportation to the work. Moreover, after reaching the work, it has to be handled most carefully, or the expenses will be run up tremendously, for it costs less to haul a block of stone several hundred miles by railroad than to move it around two sides of a large building from a storage place. Accordingly in this work most of the heavy materials have been handled by derricks from the trucks practically to the places where they will be used. All kinds of mechanical appliances have been employed, driven by steam, electricity and compressed air as was most convenient. It is safe to say that the reading of this article will furnish many new ideas to those who are unfamiliar with the work involved in such operations, and will indicate to the students in engineering colleges the technical and financial opportunities which are connected with the construction of large buildings.



Clay Street Span, 67 Feet 5 Inches Center to Center, Depth of Girder 70 Inches.

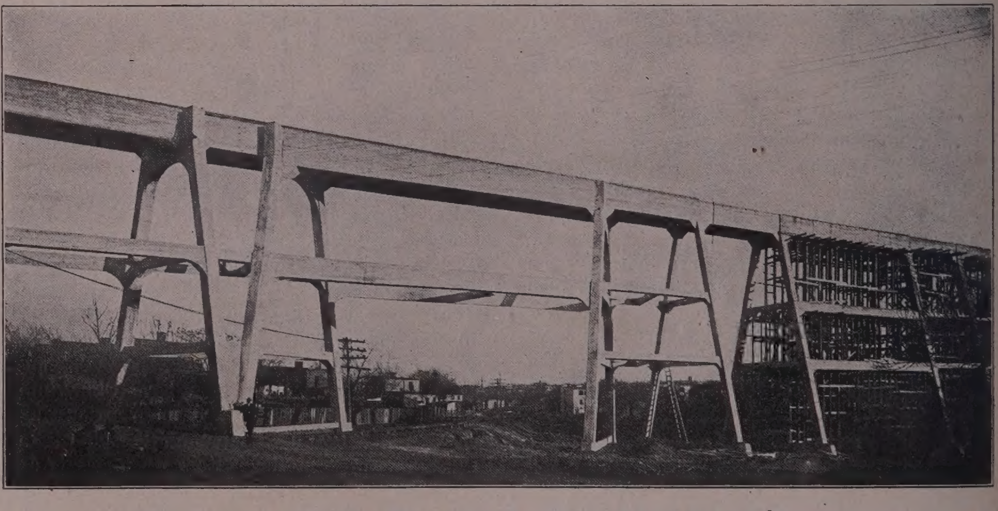
THE REINFORCED CONCRETE VIADUCT OF THE RICHMOND & CHESAPEAKE BAY RAILWAY AT RICHMOND.

The Richmond & Chesapeake Bay Railway Co., of which Mr. Frank Jay Gould, of New York, is president, Mr. Henry W. Anderson, Richmond, Va., vice-president, and Mr. William Northrop, Richmond, Va., general manager, was projected early in the year 1906, to run from Richmond, Va., to some deep water point on water tributary to Chesapeake Bay. From Richmond to Ashland, which section is now approaching completion, the line is fairly parallel to the Richmond, Fredericksburg & Potomac Railroad, though shorter and with less curvature. An electric road using alternating current of high potential, 6,600 volts, is being constructed in the most modern and substantial manner. All grades are less than one per cent., and long easy curves are used in every instance, except on the viaduct entering Richmond. Drainage and the crossing of small branches have been cared for by using 20-in. cast iron pipe and concrete arches of 4, 6 and 8 ft. span. The Chickahominy River is crossed by a steel girder bridge on concrete pedestals, and two creeks near Lakeside are crossed by concrete arches of 40 and 60 ft. span, respectively, the 40-ft. arch being full-centered and the 60-ft. span five-centered.

The company expects to do a mixed freight and passenger business, opening up a rich farming section of Virginia that is now entirely cut off from railroad facilties. Fifteen miles of road are nearing completion.

The road enters Richmond almost directly from the north, and in order to reach the property acquired for the terminal station on Broad St. it was necessary to carry the line across a wide and deep valley in which there is a small stream, practically an open sewer, called Bacon Quarter Branch. This branch is the corporation line of the City of Richmond, and is almost paralleled by the main line of the Seaboard Air Line Ry. The southern slope of the valley of Bacon Quarter Branch is solidly built up and streets on which there is much traffic occur about 300 ft. apart, so that it was important that no grade crossing be had. It was, therefore, determined to have an elevated terminal station at Broad St. and that the entire line from the abutment on Sledd St. in Henrico County should be on an elevated structure. This meant a viaduct over 2,800 ft. long and ranging in height from 18 ft. at either end to 70 ft. at the Branch above mentioned. A riveted girder viaduct was first considered, but was rejected on account of the present high first cost and cost of maintenance, as well as the difficulty of double-tracking such a structure, should this become necessary. A wooden trestle with steel girders spanning the streets only was then planned and carried so far as to have lumber ordered and partially delivered. The great danger of such a structure being destroyed by fire, as well as the necessarily temporary character of wood construction caused the officers of the company to turn to reinforced concrete as a modern, strong, permanent and handsome construction.

Maps of the located line together with profiles giving the grades and restrictions as to span and head room of street crossings, etc., were submitted to a great number of the more prominent reinforced concrete firms of the country, and they were asked to submit bids for a structure upon their own design, guaranteed to carry the prescribed loading and not to have undue deflection under a test load of double the designed load. A number of bids were received, differing greatly in design and cost. The design accepted was submitted by the New York branch of the Trussed Concrete Steel Co., of which Mr. B. J. Greenhood is chief engineer. This company was to furnish all steel for construction under the Kahn system of reinforcing concrete, and Mr. John T. Wilson, of Richmond, Va., was the successful contractor to do the construction work.



The Crossing of the Seaboard Air Line Ry. and Oak Street.

The viaduct was designed to carry a train of cars each 54 ft. long over all and weighing 150,000 lb on four-wheeled trucks placed 33 ft. center to center. The wheels on each truck were 7 ft. on centers, and thus the nearest wheels of the adjoining cars were 14 ft. center to center.

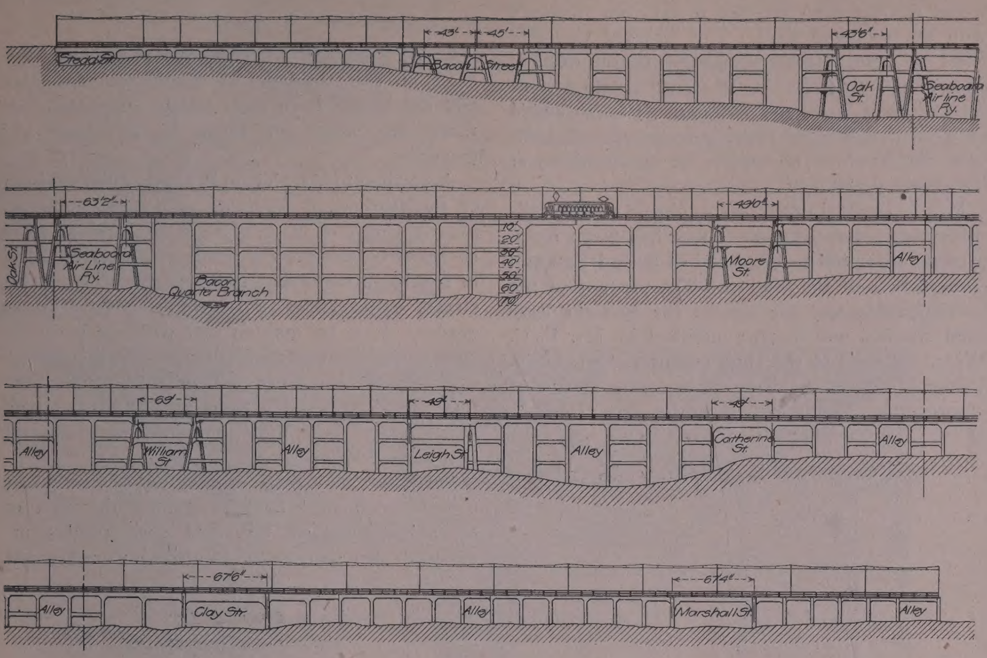
The design consists essentially of a system of girders of rectangular cross-section supported by towers. Each tower is made with two vertical bents, each having two columns 6 ft. 9 in. apart on centers at top and battered 1 to 6. They are of square cross-section and reinforced with from four to nine steel bars, the steel being placed for transverse strains only and the concrete to take the compression. The longitudinal struts and transverse braces are all horizontal.

The girders follow the grade and are rectangular in cross-section, except at the span across Marshall St. where the desired depth could not be used on account of the city limiting the company to a clear headway of 14 ft. These girders could not be made deep enough to take care of the bending moment, and as the railway company did not care to get any higher than was absolutely necessary, it became a problem of the designing engineer how best to span this street. It was found that with girders 60 in. deep, the depth allowed here, that the beam would not contain enough concrete to take the compression stresses. A T-shaped beam was finally decided on.

The spans vary in length from 23 ft. 6 in. to 67 ft. 5 in. center to center of bents, the longer spans being used at the crossings of the Seaboard Air Line Railway and streets which had to be crossed with a clear span. Expansion in the structure is taken care of by expansion joints placed at intervals of about 200 ft., consisting of a grooved steel plate on top of the bent, on which a planed steel plate on the bottom of the girder slides, while a sliding toggle near top of girder prevents any tendency to turn the girder. The accompanying general elevation shows the entire arrangement of spans. On account of unavoidable circumstances, it was necessary to put two seven-degree curves in the viaduct, both in the same direction. The grade is upward from the north end of the viaduct to about 200 ft. from the terminal, at which point it becomes level. The grade on the tangent is plus 1.10 per cent., and on curves plus 0.7763 per cent., there being a total difference in elevation of 25 ft. between the two ends of the structure.

The concrete, of a 1:2:4 mixture, was figured for a compressive stress of 500 lb. per square inch and shear of 50 lb., while the steel used was given a tensile stress of 16,000 lb.; compression, 60,000 lb. and shear of 10,000 lb. per square inch of cross-section. The modulus of elasticity of concrete to steel was taken as 1:12 and the percentage of steel to be less than 1.45 per cent.

Work on the viaduct was begun in the latter part of May, 1906, and was quite slow until the contractor got a system of operations fully established. Work was started at two points, the northern end and about the middle, and both forces worked southward. The footings for the columns were first put in, having four ¾-in. rods projecting 4 ft., around which the column was built, and also a pocket left for the bottom of the



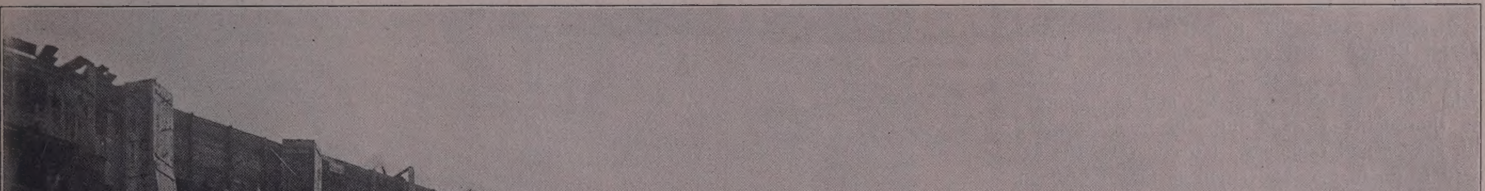
General Elevation of the Viaduct.

column. The foundations were either hard clay or compact gravel, and were calculated for a pressure not to exceed 6,000 lb. per square foot. As the structure was designed so that it could be readily double-tracked when necessary, the footings were made twice as large as they would have been if designed simply for a single track, and a 4-ft. stump of a column was left on which the future double-track column will rest. When traffic justifies double tracking the viaduct, it will be easy to construct an additional girder with proper supports, on one side of the viaduct, shift the track so that it will be supported by the new girder and one of the original girders and carry the traffic on this track during the construction of the additional girder and new track on the other side. Cored holes are provided to take care of fastening new work to the old when double tracking is begun. The footings were carried down a uniform depth of 4 ft., unless extra depth was required to get suitable foundations.

The contractor supplied suitable equipment for two concrete gangs, consisting of two No. 2½ Smith concrete mixers, two hoisting engines, elevators, buckets, etc. But it was found that while one force was erecting forms, the other was putting in concrete, and, therefore, one mixer was taken away to other work. After the erection of the forms the columns, up to the bottom of girders, and contiguous struts were poured at one continuous operation, so as to make them monolithic. Next the girders and floor were put in in the same manner. At first it was attempted to pour columns from the top, but owing to the difficulty of properly ramming and working the concrete through the reinforcing Kahn bars, this method was abandoned. The column forms were then built in a U-shape and the fourth side built up in sections as the concrete was poured.

Dumping buckets holding 3 cu. ft. and built for this express purpose were used in dumping into column forms. These buckets were lifted by means of a traveling single boom derrick, seated on top of the viaduct, and a hoisting engine. The struts were poured from wheelbarrows from the top of the structure through a 10-in. hinged pipe of galvanized iron. Concrete for the girders and floor was hoisted on wheelbarrows by double cage towers to the top of the viaduct and wheeled to position on runways on the forms.

The forms were made of 2-in. lumber, dressed on one side, and as much of the lumber as possible was cleaned and used again after forms were pulled down. The forms on the sides of the girders were removed at the end of a week, but those on the columns and the supporting falsework of the girders were left in place 30 days or longer if the lumber was not needed.



Falsework Used at the Crossing of Oak Street and the Seaboard Air Line Railway.

The smaller girder forms were supported by falsework, consisting of 4x4-in. pieces placed 3 ft. on centers along the viaduct and resting on planking placed on the ground, which had been leveled to firm bearing. Under the heavier girder forms, at street crossings, the falsework was made of 6x6-in. timbers and the struts were supported by 4x4-in. pieces, placed at distances to suit the weight carried. Owing to the great height of the structure throughout a considerable part of its length, a prodigious amount of lumber was used in the forms and shoring. Approximately 456,000 ft. B.M. was used in the entire job, or about 16,500 ft. B.M. to each 100 cu. ft. of concrete. Of course, at street crossings, and especially at Clay St., where a double-track street car line was crossed, and at the Seaboard Air Line Ry. crossing, special provision had to be made to carry the great weight of the girders. It is notable that in spite of the great weight of these girders, being considerably in excess of 50 tons each, the forms were erected and concrete put in place without delaying a train or street car.

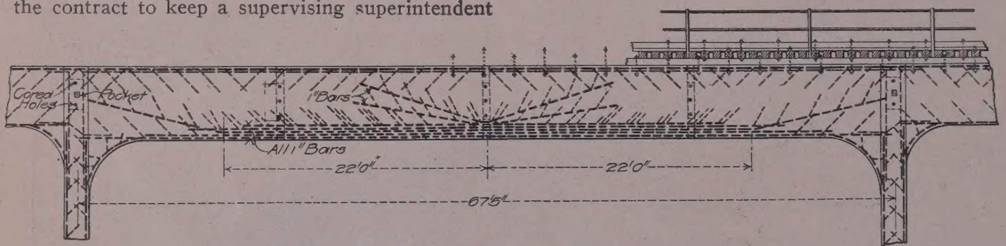
The cement used in the entire work was Atlas Portland, which was analyzed and thoroughly tested, in accordance with the specifications of the American Society of Civil Engineers, by Dr. J. M. Whitfield, of Richmond.

The stone used was granite, crushed so that all would pass through a one-inch ring, and was thoroughly screened. The sand called for in the original specifications was simply "from James River in vicinity of Richmond." This was not satisfactory to the chief engineer, and it was arranged to use a good sand obtained by dredging in the Appomattox River at Petersburg.

In the early stages of the work, comparative tests were made of mortar made from Petersburg sand and from screenings from the granite crushers at the Old Dominion Iron & Nail Works Company's quarry on Belle Isle, in James River, and as the granite dust showed a superior tensile strength of from 20 to 50 per cent. over the sand, it was adopted and used in at least 80 per cent. of the work.

The concrete in the footings was made of a mixture of one part cement, three of sand and six of stone, except that in wet pits near Bacon Quarter Branch, more cement was added. In all of the rest of the work a 1:2:4 mixture was used. This was made quite wet and the concrete was thoroughly worked into the reinforcement with spades and rammers. No concrete was allowed to go in that had stood as long as fifteen minutes.

In addition to the railway company's inspection, the Trussed Concrete Steel Co. was required by the contract to keep a supervising superintendent on the work, who was, however, paid by the contractor.



Reinforcement of Girder at Clay Street.

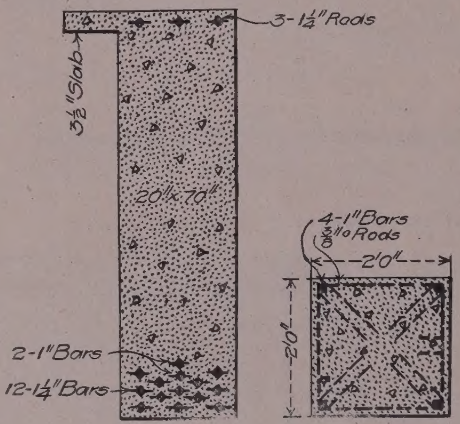
After the forms were removed, porous places in the cement were plastered up with 1:2 mortar and a finish of sand and cement applied with a brush was required.

The track rests upon 6x12-in. heart pine stringers, placed over the girders on each side. Cross-ties are 8x8-in. by 9-ft., spaced 12 in. on centers; they are oak. Every 5 ft. a ¾-in. bolt, imbedded 9 in. in the concrete, goes up through the stringer and tie, while half-way between is a bolt through the stringer only. The holes in the stringers were 2 in. in diameter and afterwards were filled up with 1:3 mortar. This was to facilitate the placing of the stringers and also to prevent any tendency of the bolts to rust off where they come out of the girder. On the outside of curves a 12x12-in. stringer was used, thus giving the proper elevation of the rail, which was full at the beginning and end of curves and dropped off ⅛ in. to each foot.

The guard rail is of 8x10-in. pine, dopped 2 in. between the ties. A walk-way is provided on the west side of the viaduct by using a 12½-ft. tie every 5 ft. and a neat hand rail of angle posts and pipe is added for safety. The supports for the trolley wire will rest on 8x14-in. by 16-ft. oak ties, placed every 60 ft. on tangents and 30 ft. on curves.

Owing to great delay in the delivery of oak ties for the viaduct, the putting on of the track has just commenced to make substantial progress, and it has not yet been possible to test the structure with the proposed load. The Trussed Concrete Steel Co. guarantees the strength of the design; and the fact that the Clay St. girder, with a clear span of 65 ft. 5 in. and weighing 54 tons, sagged only ⅛ in. when the shoring was removed, indicates that there is no reason for apprehension at the result of the tests.

Mr. J. H. McLure, chief engineer of the railroad, who furnished these notes, has given much personal attention to the detail of both design and construction of the viaduct. The amount of the reinforcement and the size of the footings have been checked and in part modified by Mr. F. C. Wyse, assistant to the chief engineer. Mr. H. T. Canty has been resident engineer in charge of construction of the entire work. Mr. John T. Wilson, of Richmond and New York, was contractor for the work, which was built by forces in charge of his superintendent, Mr. William Gibson, Jr., of Richmond.



Girder and Column Sections, Clay St. Crossing.

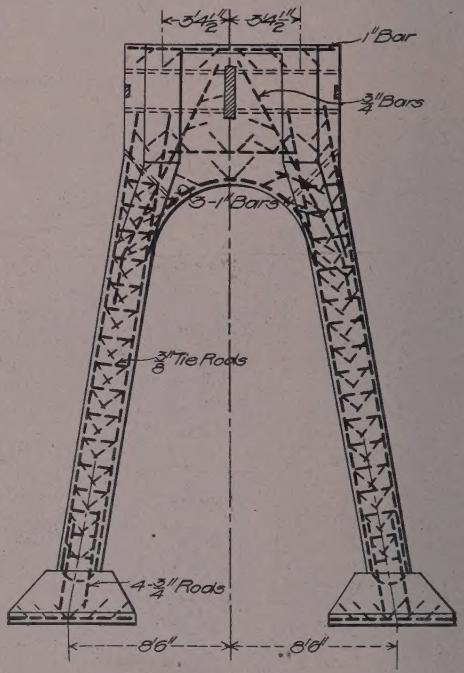
The Regulation of Vessels in St. Mary's River, so far as their movements are concerned, is the subject of some regulations recently issued by the War Department which have an interesting history. On Dec. 8, 1906, twenty vessels became fast in the slush ice in the river and for several days it looked as though some forty or more boats would be ice-bound for the entire winter. At the request of the Pittsburg Steamship Co. and the Great Lakes Tug Line, Mr. L. C. Sabin, M. Am. Soc. C.E., superintendent of the Soo canal, took charge, regulated the movements of vessels and rendered very efficient service, for which he and his assistants, Messrs. D. M. MacKenzie and L. P. Morrison received the public thanks of the marine interests. There was no law for this action and one of the ship captains declined to obey Mr. Sabin's orders. President Coulby, of the Pittsburg Steamship Co., and President Livingstone, of the Lake Carriers' Association, suggested to Col. Chas. E. G. B. Davis, Corps of Engineers, that an attempt be made to obtain legislation putting the control of the movements of vessels during such occasions under the engineer officer in charge, or his duly appointed representatives. Col. Davis submitted the regulations, which the War Department approved.

Grade Crossing Elimination in New York.

Grade crossings of highways and steam railroads in the Boroughs of Manhattan, Brooklyn and the Bronx have been mostly eliminated, but there are many of them in Brooklyn and Queens.

According to Mr. Nelson P. Lewis, chief engineer of the Bureau of Estimate and Apportionment, the mapping now in progress of the territory must be based on the present grade of the tracks, and in nearly all cases it is impracticable to carry the streets either under or over the tracks at these grades. It is his opinion that with the great increase of population and building operations which will take place in Queens in the very near future, the cost of eliminating these grade crossings will be increased by a million dollars for each year the work is delayed.

Where buildings are erected on streets having grades established by competent authorities, or fixed by years of use, and such grades are changed, the owners of improved property are, under the law, entitled to compensation for any damage to which they will be subjected. If grades have been legally established and the owners of property disregard them in making improvements, they are not entitled to such damage. The necessity of establishing grades which shall not involve railroad crossings at grade should, therefore, be done as promptly as possible.



Clay Street Bent.

Under the law the railroad companies would bear half of the expense of eliminating existing grade crossings and establishing new crossings which shall be over or beneath its tracks. In the case of elimination of existing crossings the State is supposed to pay one-fourth of the expense and the city one-fourth. In case of newly established or newly constructed streets the expense is supposed to be equally divided between the railroad companies and the city.

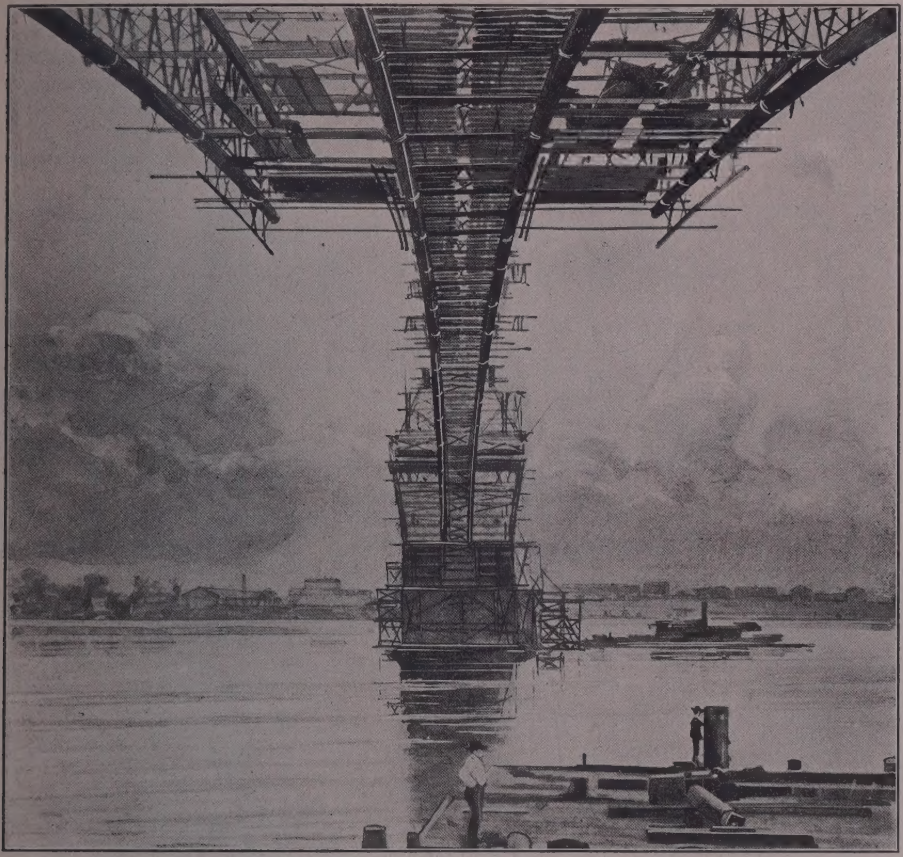
It is now regarded as extremely improbable that, with the limited amount appropriated by the legislature for this work, the city could secure any substantial contribution from the State. If the crossings are taken up one at a time the expense, which would be divided between the railroad companies and the city, would include the necessary adjustment of the railroad grades to reach the new elevation at the street to be crossed.

NOTEWORTHY EARLY EXAMPLES OF LONG-SPAN BRIDGE ERECTION.

Memoranda Regarding the Different Methods Employed on Famous Bridges.

By Frank W. Skinner, M. Am. Soc. C. E.

The history of long-span bridge erection commenced hardly more than fifty years ago because long spans themselves did not exist before then, and no spans considered long by the standards of to-day have been built more than twenty-five years. The design and erection of long spans have kept such even pace during their rapid development that it is difficult to say whether the needs of the long spans caused new methods of erection to be devised or whether the ingenuity and daring of the erectors accomplishing difficult erections encouraged designers to notably increase the length of their spans. It is evident that in this country the characteristic features of design in the pin-connected trusses here most perfected, accord well with the principles of erection which have become elementary for several types of structure; that the universal practice of building the members complete at the shops and erecting them as single units; and the methods of handling them in the field by travelers and assembling them with toggles and pilots are well adapted to each other and have permitted remarkable records of rapidity and economy of erection to be made.



Erecting Outside Trusses of Eads Bridge.

The famous Eads bridge across the Mississippi River at St. Louis for highway and double-track railroad traffic was the first steel arch and when built was of unequalled span. The design is notable chiefly on account of its elaborate construction, great cost and historical interest, the details being of a complex and expensive mechanical nature, which would never be repeated.

There are three main spans, one of 520 ft., over the channel flanked by two of 502 ft. Each span has four hingeless segmental trussed arch ribs with a radius of 742 ft. and a rise of 47 ft. and 43 ft. 9 in., respectively. The inner and outer trusses are respectively 6 and 22½ ft. from the center line of the bridge and each has parallel top and bottom chords 12 ft. apart on centers and connected by zigzag web members forming panels about 12 ft. long.

The most peculiar feature of the design is the construction of the top and bottom chords, which are made in single panel lengths, each formed of a hollow steel cylinder 18 in. in diameter, and 12 ft. long, built up with six high steel longitudinal staves forced under heavy hydraulic pressure into a thin cylindrical steel jacket and connected to the adjacent sections of the chord with screwed sleeves, through which there are horizontal pins receiving the web members and transverse braces. The railroad tracks are at about the level of the center point of the bottom chord and the highway is carried above them.

The trusses were erected as guyed cantilevers, built out simultaneously in six portions from the abutments and from the intermediate piers, the adjacent trusses balancing each other on the pier centers. The trusses, anchored at the skewbacks, were built out panel by panel with the top chords successively guyed to the tops of wooden falsework towers seated on the piers and abutments. The four trusses for each span were built simultaneously from the skewback to a point 3/11 of the distance across, after which the two center trusses were completed as shown in the picture and served as a platform from which the remainder of the outside trusses were erected.

The falsework towers on the piers were double pyramids 50 ft. high, of cruciform cross-section having a 24x24-in. oak mast and four 12x12-in. yellow pine batter legs seated on 18x24-in. oak sills with two 13-in. special hydraulic presses under each. The back stays from the tops of the towers to the anchorages were made with 6x1-in. and 7x1¼-in. iron eye-bars with sleeve nut adjustments. The tops of the towers on the Missouri abutment were anchored to cast-iron shoes set in wells excavated to a depth of 30 ft. in solid rock. The tops of the towers on the Illinois abutment were anchored to a dead man made by driving four rows of 12x12-in. sheet piles in an excavation 30 ft. deep. A 48x48-in. built oak beam was bolted horizontally across the backs of the piles and back filling was rammed around them to a depth of 30 ft. after the cables were attached to them.

The skewbacks of adjacent spans were tied together by anchor bolts through the pier masonry and were sufficiently strong to provide for the cantilever reaction until about one-fourth of the span had been erected, after which the weight of the middle trusses was carried by wire rope guys which were supported over the haunches by elaborate systems of falsework bracing to prevent undue sagging or vibrations. The stresses in the middle and side guys were 216 tons and 108 tons, respectively, and they were adjusted by screws at each end.

The arch members were assembled by a four-boom platform traveler advanced by a rack and pinion movement. The braces of the falsework towers on top of the piers were slotted to permit the tower to be raised 6½ in. by the hydraulic presses operated at 2,500 lb. per sq. in. It was very hot weather when the middle panels of the arch trusses were assembled and the high temperature produced so much expansion in the steel ribs that there was not sufficient clearance to enter the final sections and great difficulty was experienced in completing the arches. Troughs were built around one of the chords and packed with ice, but finally the last section was cut to fit and was assembled with a shorter length than called for by the original computations. The total cost of the bridge was estimated to be $10,000,000 and it is still in service after having had extensive repairs and renewals.

Scarcely second to the Eads Bridge historically or in consideration of the difficulties of erection, is the famous Kentucky River Bridge notable for being the first long span cantilever bridge as well as for being the first trussed span erected by the present cantilever method. The bridge was designed by the late C. Shaler Smith, and was built in 1875, at a height of about 275 ft. above the river, which is there subject to sudden floods of nearly 60 ft. It has two abutments and two masonry piers 375 ft. apart supporting iron towers that carry trusses 525 ft. long overhanging them 75 ft. at each end, where they support the river ends of the 300-ft. trusses of the shore spans. The bridge in service thus consists of two 75-ft. cantilever arms connected by a 375-ft. anchor span and two free end spans, but in erection all of the trusses were assembled as cantilevers.

Over fifty years ago it had been proposed to cross the river at this point by a Roebling suspension bridge of 1,236 ft. span. Work had been commenced on it and the towers and anchorages were completed before the construction was abandoned. Later when the present bridge was designed, it was determined to utilize this masonry for the cantilever re-actions during erection, and it was therefore made to serve for the anchorage of the shore spans. As the cross-sections of the truss members were not adequate to sustain the heavy erection stresses that would be developed in building them from the shore to the permanent piers, temporary wooden towers were provided midway between the abutments and the piers and served to reduce the excessive temporary stresses. The end panels of the shore spans were assembled with horizontal jack screws inserted between the lower chords and the rocky cliff and the top chords were connected to horizontal longitudinal screw rods passing through the masonry of the suspension bridge towers and having nuts bearing on horizontal transverse timbers across their rear faces.

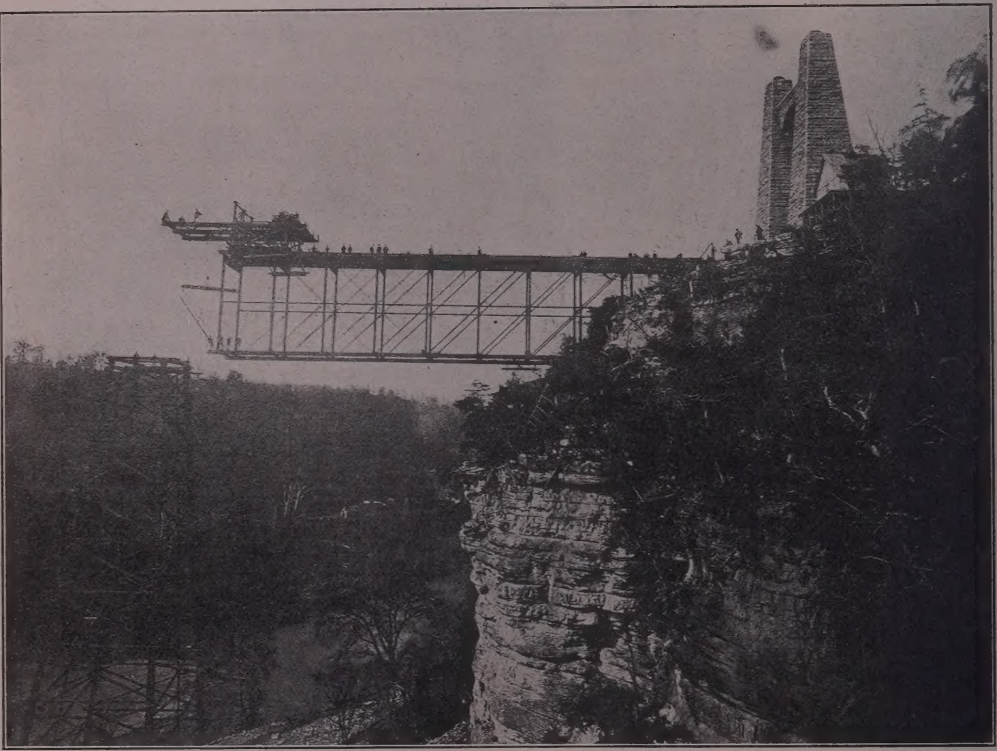
These adjustments provided for raising or lowering the ends of the trusses, which were assembled panel by panel very much as in modern erection by a light overhead traveler with an overhanging arm long enough to command one panel in advance of the finished portion of the truss. When the trusses reached the intermediate wooden towers they were landed on top of them and wedged up to bearings, relieving the cantilever stresses after which the erection was continued in the same manner until the first truss reached the middle of the center span. The traveler was then removed to the opposite shore and built out the other half of the bridge to meet it.

When the final connections were made, there was a clearance of 2 to 3 in. between the ends of the top chords, and it was found impossible to bring them in contact with the jack screws. A short delay, however, allowed the warmth of the sun to expand the metal and reduce the clearance until the splice plates matched and were bolted together. The chord pins were driven by hydraulic pressure on the assumption that they would thus be enabled to act like huge rivets. The superstructure weighed nearly 3,000,000 lb. and was designed for two ten-wheel locomotives followed by a train load covering the entire bridge. The erection was very economical and entirely successful and in view of the fact that the appliances for making the final adjustments were very limited and that no precedent existed for cantilever erection both the design and the execution of the work must rank among the most brilliant achievements of bridge construction.

The third cantilever bridge erected was the 477-ft. single-track railroad span across an arm of the Bay of Fundy, at St. John's, New Brunswick, where the 30-ft. tide, deep water and fierce current were dangerous, so that it was impossible to erect the structure on falsework. The trusses were of the double-intersection Pratt type, with horizontal bottom chords and unequal cantilever arms. The anchor arms were erected on ordinary framed falsework and the channel and the suspended center spans were erected by the cantilever method. When the designs for this work were made, the second cantilever span, that of the Niagara Bridge, had not yet been erected and no precedents were available for details of the adjustment connection between the cantilever arms and the suspended spans.

The efforts of the writer, who detailed the structure, were to secure the simplest, most economical and direct method of extending or withdrawing, raising or lowering the ends of the chords. This was satisfactorily accomplished in an entirely original manner by providing a novel tension adjustment for the top chord and a compression adjustment for the bottom chord. Transverse vertical diaphragms were riveted in the end sections of the center span to chords bored to engage the ends of horizontal U-bolts. The closed ends of the U-bolts engaged pins through slotted holes in the chords and round holes in the tops of the vertical posts in the cantilever arms, and the nuts on the opposite ends of the bolts being slacked or screwed, allowed the top chords to move out or carried them in against the weight of the span. The end lower chord pins passed through round holes in the members of the cantilever trusses and through slotted holes in the lower chords of the suspended center span. Steel castings were riveted into the ends of the lower chords and were tapped to receive double pairs of heavy steel stud bolts with their hemispherical shore ends engaging cast steel bearing plates riveted to the lower ends of the vertical posts. The opposite ends of the bolts were provided with heads fitted to powerful S-wrenches which, during erection were easily operated by four men at each panel point, 16 in all, who with an equal number on the top chords, were thus enabled to easily lower the bridge and adjusted the center panel to receive the closing members.

Of course these adjustments were not equal to the wedge and roller device afterwards developed for cantilever erection, but it had the advantage of simplicity and low first cost and was after all so successful that when the Interprovincial Bridge at Ottawa was constructed by the same company many years afterwards, substantially the same erection adjustment was adopted. The use of short eye-bars, telescopic struts and finished wedges and rollers was thus avoided, but on the other hand the inexpensive U-bolts, diaphragms and castings were permanently engaged in the final structure.



Landing Cantilever Arm of Kentucky River Bridge on Temporary Intermediate Tower.

The shore arms were erected on ordinary framed falsework and their extremities were anchored by vertical eye-bars to reaction platforms built into the lower part of the pier masonry. The traveler used for the erection of the anchor arms consisted of a wooden tower about 100 ft. high, equipped with a six-spool steam hoisting engine, the latter being probably the first of its kind used for bridge erection. With this traveler the very tall pier post, nearly 90 ft. high, was erected and the first panel of the cantilever arm was assembled.

For the erection of the cantilever arm a small traveler consisting of a rolling platform mounted on the inclined top chord was built, and had at the forward end a vertical bent with two transversely braced vertical posts, guyed to the rear of the platform. From the tops of these posts other guys reached to the forward extremity of the projecting arm 36 ft. long, which was sufficient to reach 1½ panels in advance of the completed structure and thus enable a new panel to be assembled and the connections of the intersecting double-panel diagonal bars to be made. The two sills or booms of the overhang served as jigger beams, from which manila tackles were suspended and were operated by the hoisting engine carried on a truck running on the permanent track laid on the bridge floor. Light working platforms were suspended by hand tackles from the end of the overhang and particular care was necessary to keep the traveler constantly anchored by preventer tackles to the tops of the pier posts to prevent it running down on the inclined top chord eye-bars, which carried the tracks for the traveler wheels.

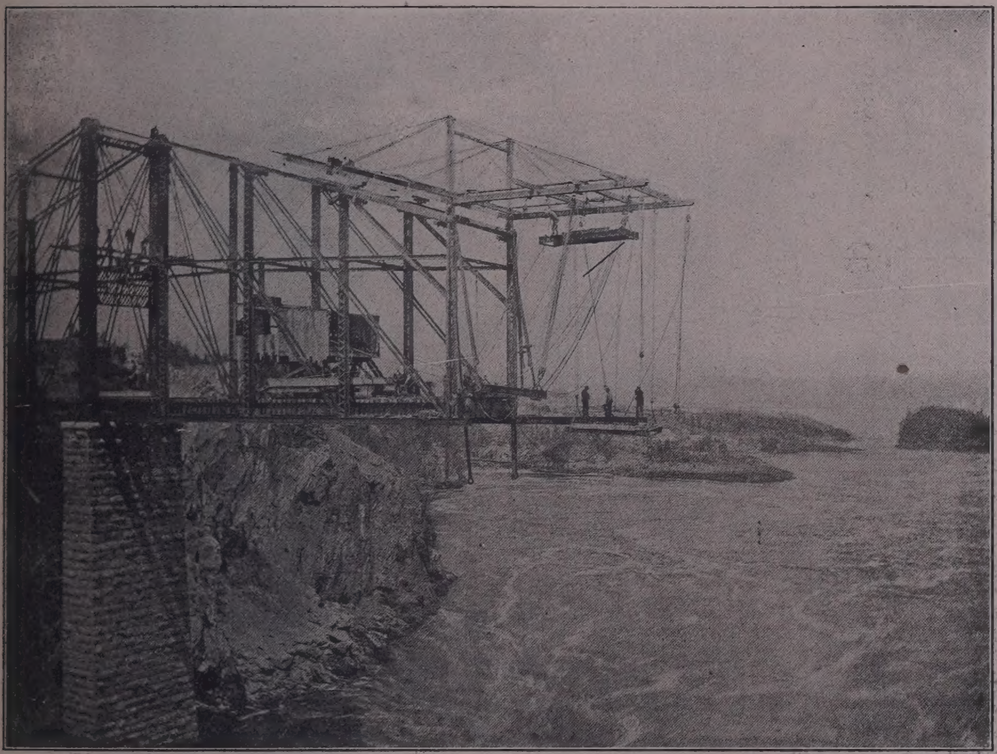
As the erectors were unaccustomed to work of this nature. it was carried on slowly, and had to be suspended during the inclement winter of this latitude. One anchor arm and the corresponding cantilever arm and half of the suspended span were erected and the traveler was transferred to the other side of the river and erected the other half of the bridge with a small force of men in about four months actual working time.

The Poughkeepsie double-track railway bridge across the Hudson River has a total length of 6,767 ft. and a clear height of 130 ft. above the river. The river crossing is made with two intermediate 525-ft. anchor spans and three cantilever spans alternating with them, having lengths of 546 ft. and 548 ft., together with two shore anchor spans 201 ft. long and lofty approach viaducts at both ends. The sub-structure work was discontinued in 1873 and recommenced in 1886, the erection of the superstructure being commenced in 1888.

The height of the track, the depth of the water and the character of the bottom was such as to greatly increase the difficulties of all parts of the construction. The foundations were carried to solid rock at a depth of 145 ft. below high water level so that they were far beyond the limits of pneumatic caisson work and had to be made with open cribs, dredged and concreted under water. The two 525-ft. deck spans have double intersection, pin-connected trusses 30 ft. apart on centers and 75 ft. deep, which were erected on framed falsework seated on pile bents. The 201-ft. anchor spans were also erected on framed falsework which was built simultaneously with that for one of the 525-ft. spans. One of the 548-ft. cantilever spans was then erected, the falsework was removed from under the first 525-ft. span and replaced for the second 525-ft. span which was then erected, after which the other 548-ft. cantilever span and the center 546-ft. cantilever span were successively erected, completing the structure.

The shore arm falsework had framed trestle bents with seven stories from 18 to 23 ft. in height seated on transverse sills, 75½ ft. long. Each bent had two vertical posts about 30 ft. apart on centers and four battered posts diverging from the tops of the vertical posts to the ends and center of the bottom sill. Two vertical posts were seated on the extremities of the fifth story cap and together with two slightly inclined intermediate posts supported the seventh story cap on which the material track, traveler track and camber blocks were placed. All posts were cut to one-story lengths and were spliced across the caps and sills by double wooden scabs. All posts, caps and sills were made of 12x12-in. timber and were braced transversely by 4x10-in. diagonal planks. All bents were braced longitudinally with four lines of 12x12-in. ledgers at each cap and were X-braced in every panel with 4x10-in. diagonals. The sills were carefully bedded on the level surface of the ground or were set on timber grillages.

Each panel of the 525-ft. span was supported on four falsework bents, one located at each subpanel point and one on each side of each bottom chord main panel point. Each bent was about 120 ft. high from the top of the 60-ft. double cap to the 100-ft. sill. It had eight battered 12x12-in. posts, three of them grouped under each truss and one at the extremity of the cap. Each story had three panels of 4x10-in. transverse X-bracing and the longitudinal bracing corresponded to that of the anchor arm falsework.



Erecting Cantilever Arm of St. John's Bridge.

The sill of each framed bent was seated on a 12x12-in. 101-ft. cap of a pile bent, at a height of about 20 ft. above water level. Each bent contained eight groups of three piles each, one group located under the foot of every post in the falsework bent above. Each pile was made with two pieces 15 in. in diameter and 60 ft. long butt jointed and spliced together with eight long wooden fish-plates. It was driven to rock through about 50 ft. of water, 20 ft. of mud, 45 ft. of clay and fine sand and 17 ft. of gravel. The piles were connected with longitudinal and transverse ledger pieces just below water level and the panels between them and the caps were X-braced similar to the falsework, all connections being made with ¾-in. bolts in ¾-in. bored holes.

The falsework for this span had a bottom width of 100 ft., height of about 240 ft. and contained over 2,000,000 ft. b. m. of pine and hemlock timber. It was proportioned to carry its own weight, estimated at 10,000,000 lb. plus 3,000,000 lb. for traveler and engine, and about 4,000,000 lb. of steel, besides a concentrated hoisting load of 70,000 pounds, and to resist lateral motion, vibration and the effect of ice and current.

The traveler for the 525-ft. spans was a 62x70-ft. wooden tower, 95 ft. high, mounted on 32 double flange wheels on two standard gauge tracks about 51 ft. apart on centers. The tops of the bents were made with transverse trusses which supported two 8x16-in. wooden jigger beams over the center line of each truss. It had horizontal and vertical clearances of 38 and 80-ft. respectively. The principal members were 10x10-in. timbers X-braced transversely with 3x8-in. planks and having longitudinal 4x12-in. ledger pieces and 1¼-in. screw end X-brace rods.

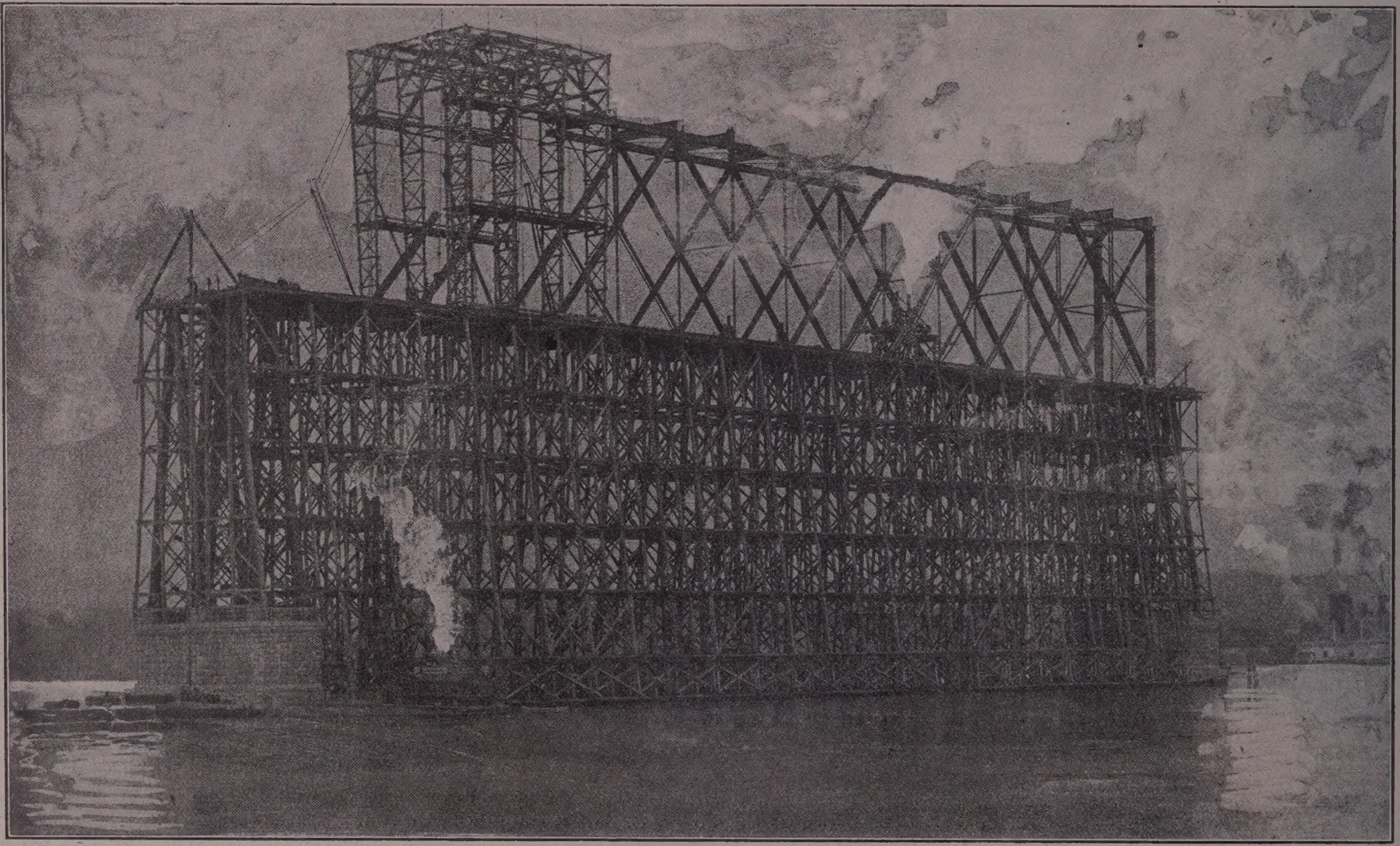
This traveler was larger and taller than any that had been previously built, and its construction was a record for erection work. Its bents were separately assembled in a horizontal position, with the feet of the posts in the first bent abutting against wooden blocks securely lashed to the top of the 130-ft. falsework. Guys and tackles were attached on opposite sides to the top and middle of the bent, and the upper end was blocked up a few feet above the falsework. The lead lines of the tackles were made fast to the drums of the hoisting engine, and the latter being operated, gradually revolved the bent into a vertical position, care being taken to keep all of the guy lines taut. Mr. Robert Baird, the superintendent of erection, stood on the cap of this bent and rode up as it gradually revolved into position, directing the operation of the hoisting engine by signals. The bent was guyed in a vertical position and from it tackles were suspended by which the other bents were successively revolved into position.

The traveler was equipped with ten sets of 1½ in., six-part manila rope tackle operated by a hoisting engine stationary on the successive piers. The heaviest load lifted was a 68,000-lb. top chord section. The traveler commenced erection at the middle of the span and after completing one-half of both trusses, returned to the starting point and worked in the opposite direction until the span was finished. Most of the steel work was delivered on scows, moored to the pier, and was hoisted by a boom derrick to the top of the falsework and distributed there on the material tracks between the trusses. The 201-ft. spans were erected by the travelers used for the 525-ft. spans and the steel for them was similarly delivered and distributed.

The cantilever spans were erected by two overhead wooden travelers running on the horizontal top chords. Each had two trusses, about 118-ft. long, 22 ft. deep and 34 ft. apart on centers, made with horizontal wooden top and bottom chords and vertical posts and iron diagonal rods with screw ends and nuts bearing on angle blocks. Both top and bottom chords were braced together at panel points with wooden transverse struts, but only the forward panel between the bottom chords was X-braced with screw rods. The rear ends of the trusses were seated on longitudinal sills with bearings at panel points. Each sill was supported at three points, namely by one wheel at the rear, by two wheels 31⅓ ft. from it, and by three wheels 31⅓ ft. from the second set, thus giving it a base 63 ft. long and an overhang of 40 ft. The trusses were connected in the overhang by 1½-in. X-brace rods in vertical transverse planes at panel points. The rear end of the traveler had two intermediate vertical posts about 20 ft. apart, connecting the top and bottom transverse struts at every panel point, thus making three panels, the two outer ones of which were X-braced with screw-end 1¼-in. rods. A pair of mast and boom derricks at the rear end of the traveler served to transfer the bridge members from the service track to a short length of track running through the traveler and delivering to tackles suspended from transverse jigger beams on the overhang. The rear end of the traveler was anchored to the finished superstructure by screw clamps at the two forward trucks, adjacent to which jackscrews were also provided to raise the wheels clear of the track when the traveler was in service. The rear end of the traveler was floored to supply storage space and support a six-spool hoisting engine.

Both travelers were followed by a small wooden tower traveler mounted on six wheels which carried on top a turntable with a platform having a cantilever extension like a small girder crane on which a trolley and differential hoist supported a yoke riveting machine. The platform above the turn-table was equipped with a steam engine, hydraulic pump, accumulator and rivet forge and shears. Longitudinal, transverse, vertical and rotary adjustments enabled the riveting machine to command the rivets in the floor system or chord splices. The plant required for the erection of the bridge, although inconsiderable in comparison with that now furnished for large structures, was considered exceptionally large and complete at that time. It included two dredges, eight hoisting engines, two pile drivers, fourteen scows and three steamboats, besides which there was a large amount of small tools, jacks, lines, tackle, etc. More than 40 sets of tackle with 15-in. sheaves, and 2,500-ft. of 1½-in. manila line each were used. The hoisting engines, with some novel features, were built especially for this work, and were considered heavily loaded with a 34-ton chord section. About 140 bridge men were employed on the erection, and made a record of hoisting the material for 108 lineal ft. of truss, 130 ft. high and connecting it complete in one day. It was believed that if there had been no delay for material, one 525-ft. span would have been hoisted, assembled, connected and swung complete in 12 days.

The Washington Bridge, New York, carries a 50-ft. highway and two 15-ft. sidewalks across the Harlem River at a height of 130 ft. above the water, and was built about 20 years ago at a cost of over $2,000,000. The two channel spans each have six 2-hinge plate girder arch ribs 14 ft. apart of 510-ft. clear span supporting vertical spandrel posts and a buckle-plate floor. The ribs are 13 ft. deep and have variable lengths corresponding to a uniform horizontal projection of about 15 ft. These dimensions were so great that the segments could not be shipped in the ordinary manner and platform cars were provided which had slots cut through the floor in which the web girders were seated in vertical planes, the lower flanges just clearing the track between the rails. The land span was erected on thirty-four framed falsework bents, one for each section of the arch. Twenty-seven of the bents were seated on transverse sills, 72 ft. long, made in three lengths, spliced with bolted wooden fish plates on the vertical sides, and laid in trenches 1 or 2 ft. deep. The other seven bents were seated on plate girders spanning the highway and railroad tracks. All bents were made in 20-ft. stories and each had six vertical, 10x10-in. posts, one in the plane of each rib. The sections of the vertical posts were separated by 10x10-in. caps at every story and the pairs of vertical posts were X-braced together in three sets with two open panels in the alternate spaces between them. Four long inclined posts extended from the top of the falsework to the bottom on each side of the center to brace it against unbalanced thrust due to the partly erected steel work. The bents were braced longitudinally with 3x10-in. ledger pieces at every story and with single diagonal planks in each panel; beveled bearing pieces were seated on the upper caps to receive the rib girders and were arranged so that cribbing might be built on both sides of them and provide for the insertion of hydraulic jacks to lift the steel work and swing the completed span. The channel-span falsework was similar to that of the shore-span except that the framed bents rested on sills 90-ft. long carried on eight piles and extending 14 ft. beyond the falsework on each side to serve as a protecting fender. An 86-ft. opening through the center of the falsework provided for navigation and had a vertical clearance of nearly 90 ft. It was made by inclining toward the center at the top two bents of the framed falsework on each side, and connecting their upper ends with short wooden trusses.



Erection of Intermediate Free Span of Poughkeepsie Bridge.

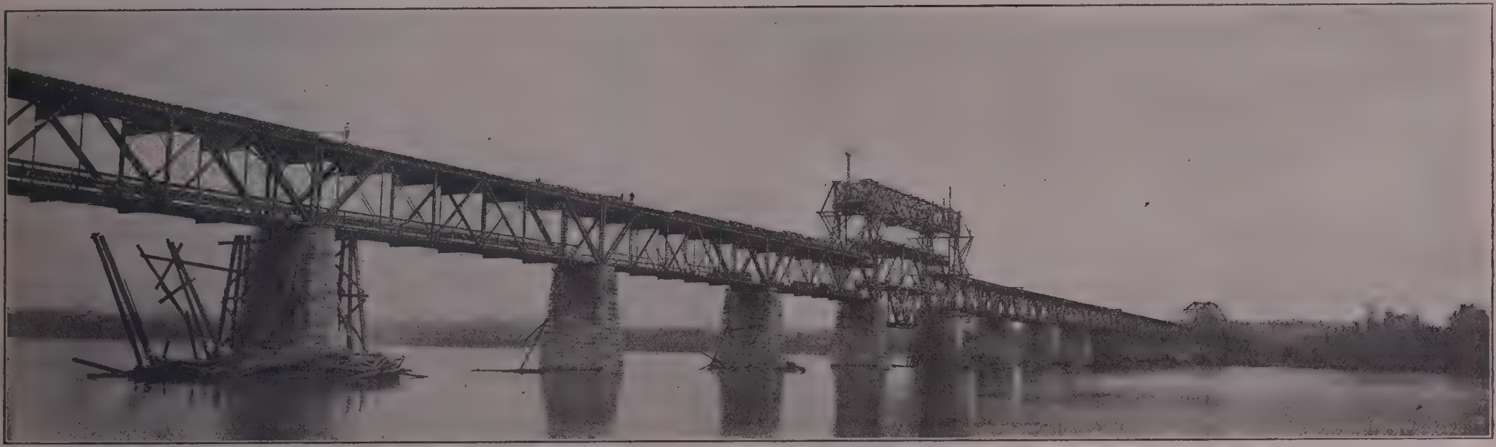
Material was delivered on railroad tracks running through the land falsework and was hoisted from them by a T-shaped double balanced cantilever revolving derrick mounted on a low level service platform extending from end to end of the bridge adjacent and parallel to the falsework. Materials were distributed on this platform and were hoisted to position as required and set at one operation by the traveler derricks. Over 500 piles and about 1,500,000 ft. b.m. of timber was required in the falsework which was chiefly composed of 10x10-in. hemlock vertical posts and 3x10-in. diagonals. The erection of the arch ribs was commenced simultaneously at both skewbacks and carried forward by two travelers meeting at the crown. Each traveler consisted of a skeleton platform covering the three center panels of the bridge and provided at the upper or forward end with a vertical transverse framework having two derrick masts, each of them fitted with a 40-ft. boom. The masts were hinged at the bottom so as to always be maintained in a vertical plane regardless of the varying angle that the platform made with the horizontal and were secured by adjustable stiff legs and guys to the rear end of the traveler. The lead lines from the hoisting and topping tackles were run to hoisting engines stationarily located on the falsework under the bridge. After the completion of the arch ribs the erection of the vertical spandrel posts and floor platform was commenced at each end of each span and carried forward simultaneously to the center by duplicate overhead travelers consisting of horizontal platforms with two boom derricks mounted on the forward corners, which rolled on the finished floor stringers.

This bridge was one of the first in which field rivets were driven by machinery. Nearly all of those in the splices of the arch ribs were driven by a yoke machine suspended by a differential hoist from a trolley running on a longitudinal round bar that rolled transversely back and forth across the span on the tops of the horizontal spandrel braces. The two arch spans weigh about 3,342 tons and were erected by 200 men in about seven months, including the coldest winter weather. During the erection there occurred an accident to one of the employees whose escape from serious injury or death is one of the most miraculous on record. A man fell over 100 ft. from a point near the upper part of the falsework and struck head first in the shallow water, penetrating some distance in the very soft mud, above which his legs appeared waving signals for help. His companions were able to extricate him comparatively uninjured. He was taken to the hospital and discharged from it in time to return to the bridge before its completion.

The Panther Hollow bridge carries the highway across a deep ravine in Schenly Park, Pittsburg, at a height of about 125 ft. above the water. It has four spandrel braced three-hinge arch trusses of 360-ft. span and 45-ft. rise, 5 ft. deep at the crown and 50 ft. deep at skewbacks. The top and bottom chords have rectangular cross-sections made with built channels and cover plates. As the parabolic curve of the bottom chord corresponds to the moment diagram of the fully loaded truss, it is evident that under dead load alone no stresses would exist in horizontal or diagonal members. Provision was therefore made for the erection of the trusses under dead load alone and for special connections intended to receive the live load stresses only. The total steel weight is about 2,016,000 lbs., and the estimated live load for the trusses is 89 lbs. per sq. ft. of the roadway.

An unusual feature of the erection was the assembling of the semi-spans independently, one half of the bridge being erected on separate falsework before the erection of the other half was commenced. The falsework for each half of the span consisted of two towers each supporting the lower chords at three-panel points. In each tower there were three bents each having six vertical and two batter posts, seated on a long sill. The center towers had six stories and were X-braced transversely and longitudinally in every panel between posts and horizontal members. The arch trusses, cantilevered beyond the falsework towers, one panel each side at the crown. The truss members were connected at panel points by small pins proportioned for double dead loads only, and received the full erection stresses. After the bridge was swung the holes for the field rivets were reamed and the splice plates were riveted with joints proportioned with a 30 per cent. excess for double live loads only.

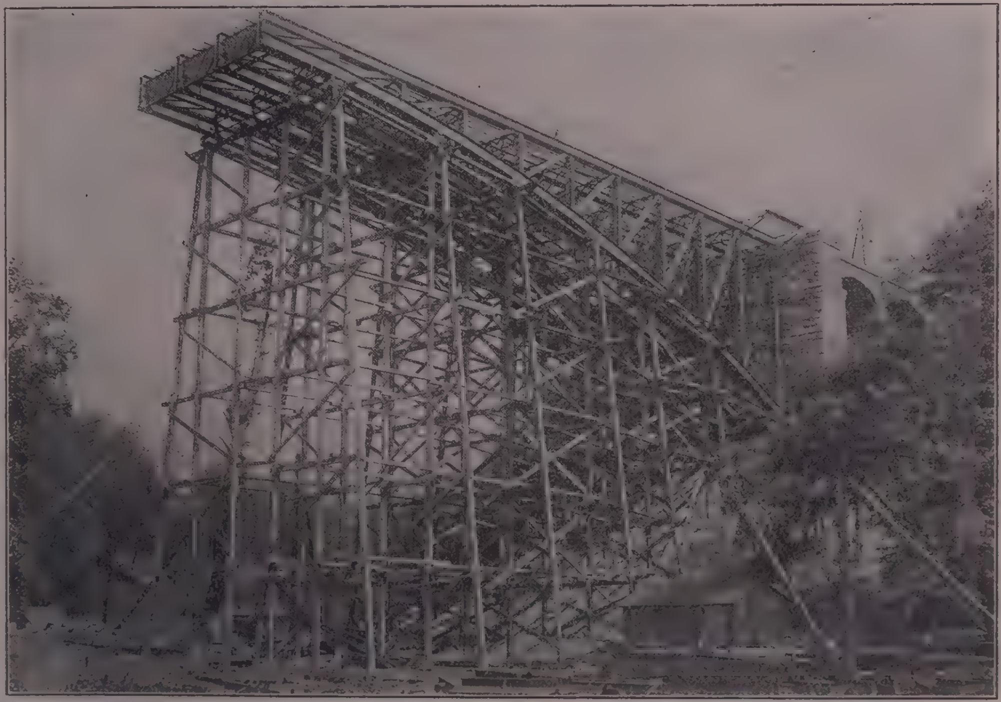
River Span of Washington Bridge.



Lowering Old and New Spans of Florence Bridge from Traveling Falsework Span.

The single track of the East Tennessee, Virginia & Georgia Railroad crosses the Tennessee River near Florence, Ala., on a bridge 1,572 ft. long, which includes twelve deck spans 115 to 120 ft. long. The railroad track is carried at the top chord level and the highway is carried between the trusses at bottom chord level. About 15 years ago the old superstructure was replaced by a new one on the same substructure and as it was required that the old structure should be removed and the new one substituted without interruption to railroad or highway traffic it was determined to build each new span directly above the corresponding old one and then to rapidly lower the old span as a whole to the water, simultaneously replacing it by the new completed span which descended simultaneously into its final position and immediately received regular traffic.

The old spans were not considered strong enough to sustain the additional loads from dead weight of the new ones, and the latter were therefore successively supported during construction by a traveling span on top of the old bridge and clearing its railroad traffic. The traveling span, 150 ft. long over all, had two wooden Howe trusses 14 ft. 8 in. deep and 16 ft. apart on centers. The end vertical posts were supported on rolling towers, 23 ft. high, each having four double-flange wheels, tandem on each rail of the 16-ft. gauge track laid on the old top chords.



First Half of Panther Hollow Bridge.

The 155-ft. end span of the old bridge was replaced by a new span built on falsework. After its completion the traveling span was erected on its top, a temporary tower was placed under the centers of the trusses to reduce the load on the end towers and distribute it over the old span, and the traveler was advanced to take its position over the second span of the structure with the towers just outside its piers. The top chords of the new span were suspended by adjustable connections from the bottom chords of the traveling spans and the remaining members of the span were assembled to the top chords and to each other, so that eventually the total weight of the span was suspended from the traveler.

The end floor beams of the new span were provided at each end with a yoke made with vertical screw rods and top and bottom transverse beams. Each yoke engaged the lower end of a 3½-in. vertical screw 36 ft. long. The upper ends of these screws were fitted with nuts geared with a 1:30 reduction to a 6x6-in. steam engine, and having anti-friction horizontal bearings on the top of the traveling span.

Auxiliary 12x12-in. vertical shores were wedged under the bottom chords at both ends of the traveler and transferred the bearing from the bases of the towers, transmitting the loads directly to the tops of the piers. The top chords of the old span were temporarily connected to the bottom chords of the new span at panel points, highway traffic was temporarily diverted from the old bridge, during one of the longest regular intervals between trains, the end panel members were removed from the old trusses, pedestals were seated on the masonry for the new trusses, and all being in readiness, the nuts on the vertical screws were slacked off by the engine and both spans were simultaneously lowered about 22 ft. in one hour actual working time. The new span thus displaced the old span in its former position and the old span descended to a position where it was entirely out of the way and could be removed at leisure. The bridge was out of service only about four hours during the erection of each span. After the completion of one span, the traveler moved forward to the next pier, replaced another span, and so on, until the erection was finished. The reactions from the three towers of the traveler span when in transit, were as follows: Timber weight, 34,000 lb.; iron, 12,000 lbs.; machinery, 19,000 lbs.; for each end tower, timber 47,000 lbs.; iron 52,000 lbs.; for the temporary center tower: total, 102,000 lbs. The entire steel weight of the new superstructure was about 1,620,000 lbs., and it was erected in 80 days by an everage force of about 34 men.

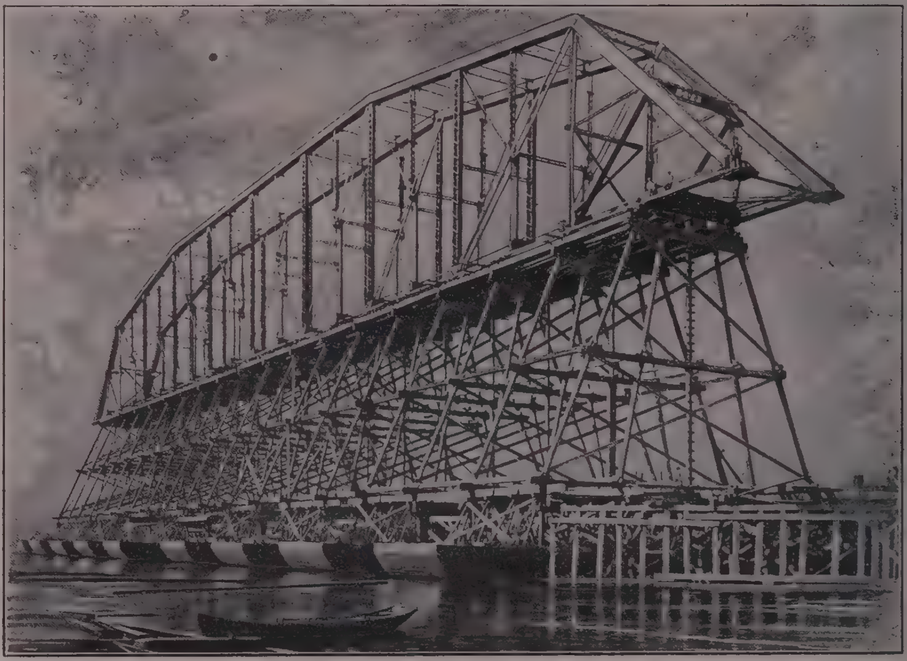
The Ohio Connecting Railroad crosses both channels of the Ohio River and Brunot's Island, a few miles below Pittsburg, on a single-track bridge 4,568 ft. long. The structure includes two long approach viaducts, a number of short pin-connected deck spans and two long, high channel spans, all of which were erected in the usual manner with falsework and traveler except the 525-ft. and 416-ft. spans over the main and side channels respectively. The main channel carries constantly a very large traffic of steamboats, tugs and other craft, besides large fleets of coal barges which are grouped together three or four abreast and six or eight long, and are pushed downstream by a stern-wheel steamer in the rear. These, together with large rafts of timber pushed in the same way, are very unwieldly and cannot, of course, be very accurately or positively controlled. To avoid danger from them as well as from the sudden violent floods to which the river is subject, and also on account of the wishes of the river men, it was decided to dispense with ordinary falsework in the construction of the bridge and not to obstruct the channel at all at this point.

A somewhat sheltered point was accordingly selected near the bank of the island, about 1,000 ft. below the bridge, and there falsework was built parallel with the shore and near to it at the required height for the 525-ft. main channel span. The truss panels were about 26 ft. long, but for reasons which will be hereafter apparent, the falsework bents were not exactly centered on them but were made with alternating panels of about 26 ft. and 30 ft. The upper part of the falsework was made with framed bents supported on transverse pile bents braced together longitudinally in alternate pairs so as to form towers with open panels, 30 ft. wide between them. The open panels were spanned by 24-in. longitudinal I-beams about 32 ft. long resting upon the transverse pile caps. Five pairs of I-beams, one pair over each longitudinal row of piles, supported the 12x12-in. 43½-ft. sills of the frame trestle bents above them.

Each framed bent had one center vertical post and four side posts battered much more than usual so as to give an extraordinarily wide base for the falsework. The connections were made unusually strong, and the bents were X-braced longitudinally with pairs of 1⅞-in. screw end rods, but in other respects the falsework was of the ordinary pattern, and on it the trusses were erected in the usual mannner with both ends overhanging as cantilevers about two panels long. The framed falsework was 57 ft. high above the tops of the pile bents and the distance from water level to the tops of the finished trusses was about 145 ft. The trusses were erected by an ordinary gantry traveler 78 ft. long and 69 ft. high, which was removed after the trusses and other members of the span were assembled.

Nine 26x130-ft. barges, 8 ft. deep, were each provided with five transverse towers 18 ft. high. Each tower extended across the full width of the barge and had one center vertical bent and two inclined side bents all resting on longitudinal timbers distributing their weight over the full length of the boat. The end towers each had an additional inclined outside bent at the foot reaching to the end bulkhead of the boat. The tops of the towers were capped with 6x8-in. timbers 42 ft. long and about 24 ft. apart on centers, parallel with the axis of the barge.

These barges, heavily ballasted with water, were towed into the open spaces between the pile falsework towers. The water ballast was pumped out until the increasing buoyancy of the barges forced the transverse caps on their towers against the lower flanges of the longitudinal I-beams supporting the falsework and gradually lifted the entire super-structure of framed falsework and steel span free of its original support on the piles. Diagonal tie-planks were then bolted to the sills of the falsework and the caps of the barge towers, thus forming a certain degree of connection between the falsework and the barges.



Floating the Brunot's Island Bridge.

Several steamers were attached to the barges and very carefully drew them away from the pile falsework. As soon as they were clear of the piles the barges were connected across the open spaces by five longitudinal lines of horizontal timbers and each pair of barges was X-braced together by two sets of ⅞-in. diagonal adjustable rods. The river being at full pool with very slight current somewhat reduced the difficulty and danger of towing such a flexible and top-heavy structure by several independent lines.

Navigation near the bridge site was temporarily suspended and the steamers and tugs gradually revolved the barges supporting the spans about 90 deg. and then towed them up stream to a position between the piers of the channel span where they were carefully secured for the night and temporarily protected by a line of barges parallel to them, forming a fender to prevent collisions from boats or other objects.

Each barge was divided into four compartments by water-tight bulkheads, and in each compartment there were two holes closed by long plugs, which were withdrawn and partially scuttled the barges, gradually settling them until the bridge was deposited with its pedestals engaging seats on the masonry piers. The settling was continued a little while longer to clear the falsework from the span, after which the plugs were replaced, the barges withdrawn from underneath the span, pumped out and returned to the position where the first span had been erected, where they were again scuttled and deposited the falsework on the pile bents, in readiness for the erection of the similar 416-ft. span for the other channel which was transported to position and deposited on the piers in the manner already described. Both erections were entirely successful and attracted great attention among engineers and contractors.

Block Signals in Massachusetts.

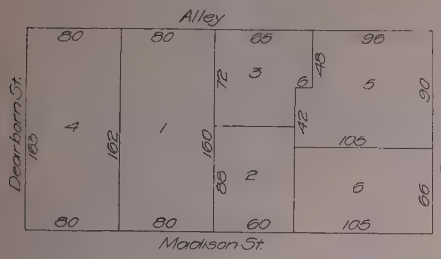
The Massachusetts Railroad Commission has been investigating the block signal systems of this and other countries and has reached the conclusion that there is no reason for adopting here the foreign fashions in respect to these safeguards. In its opinion the block systems of the Pennsylvania R. R. and the Central R. R. of New Jersey between Jersey City and Philadelphia, and that on the Hudson division of the New York Central lines are of the highest order of excellence. The work before the Massachusetts companies is the complete installation of such signals on all lines of track, in accordance with the following order from the Commission:

"(1.) The ultimate end to be secured is the installation of some approved form of block signals upon all steam railroad lines within the State at as early a day as may be practicable. This means a substantial outlay by railroad companies in the immediate future.

(2.) The order in which block signals should be installed must have reference to both amount of traffic and physical conditions. Of first importance is the equipment of lines of railroad embracing two or more tracks, or presenting the conditions of a single track carrying a large amount of traffic and involving heavy grades and sharp curves. Local conditions may of course demand at particular places early equipment out of the usual order.

(3.) Companies are requested to submit to the board on or before Dec. 4 a brief description of the block signals now in use upon their several lines within the State, together with an explanation of such action as has been taken in either actually equipping these lines or in making arrangement for their future equipment with block signals, since the first day of January, 1906."

The Commission considers that no type of signal system shows marked advantages.



Plan Showing Order of Work by Sections.

Shoring a Fifteen-Story Office Building in Chicago.

The Champlain store and office building at the northeast corner of Madison and State Sts., in Chicago, is a fifteen-story and basement structure, 65 x 105 ft. in plan, that was one of the earliest of the tall buildings with steel-cage frames to be erected in that city. The design of the steel frame is in many respects different from present practice, and the outside brick walls are partially self-supporting and are carried partially by beams in the steel frame at the various floors. The columns of the steel frame were set on broad footings consisting of several layers, or grillages of steel I-beams incased in concrete. These footings had their tops flush with the floor of the basement of the building and were built on the upper stratum of blue clay that overlies solid rock to a depth of about 110 ft. at the site. This clay varies from dense hardpan immediately over the rock to a semi-plastic material at the surface that flows freely when heavy loads are placed on it, if it is not confined.

The footings of the Champlain Building were designed, like those of many other structures erected in Chicago during that period, to have sufficient bearing area on the soft clay so they would practically float on the latter. This type of building footings was for a long time considered the most efficient that could be designed to meet the conditions. These footings really served their purpose well so long as no excavations were made in the vicinity of the structure carried by them. The construction of the freight tunnels of the Illinois Tunnel Co. at an average depth of 42 ft. below the street grades under practically every street in the business district of the city, together with the rapidly increasing value of property, have resulted in practically all new buildings of any size in the district served by the tunnels being built with three stories below the street grade, the floor of the lowest one being at the level of the tunnels. The excavations required for these underground stories has in numerous cases resulted in considerable settlement of adjoining structures, the steel-cage buildings with the spread footings being affected as well as the old style structures with solid masonry walls and footings.

A department store building with three floors below and fourteen stories above the street grade is being erected on the remainder of the half block on which the Champlain Building stands, and will form with the latter a combined building 192 x 360 ft. in plan. This combined building will face on three streets with a 16-ft. alley at the rear, and with the exception of the upper stories of the older structure will be occupied by the Boston Store. The three basements and the first seven stories of the new building, which is a steel-cage fireproof structure with its columns built on circular concrete footings, 8 to 12 ft. in diameter, carried down to bed rock 110 ft. below the street grade, are first being completed over the entire site. The footings, substructure and steel work are designed, however, to carry the full fourteen stories. The excavation for these basements has to be carried down 42 ft. below the street grade while that for retaining walls built around them extends 52 ft. below that level. These deep excavations have necessitated some of the heaviest and most difficult shoring work to hold the Champlain Building and other buildings on adjacent sites in their positions that has probably ever been undertaken.

In order to meet business conditions the new building had to be erected in five separate and distinct sections as indicated on the accompanying outline plan. The Boston Store occupied the lower six floors of the Champlain Building and an old 6-story building on each side of the latter as indicated by sections Nos. 2, 3, 5 and 6, on the plan. The remainder of the site, shown as sections Nos. 1 and 4 of the new building, was occupied by several old brick and stone office buildings of various heights. The possession of the old buildings on the site of section No. 4 could not be obtained at the time construction was started. It was also necessary that before any of the structures occupied by the store be removed an amount of space should be available in the new building at least equivalent to that vacated in the structure to be wrecked. Accordingly, section No. 1, 80 x 162 ft. in plan, was erected first and was followed by the erection of sections Nos. 2 and 4, section No. 3 having at this time also practically reached completion.

The Champlain Building.

The shoring work on the old buildings on each side of section No. 1 and on those across the alley from the latter was quite fully described in The Engineering Record of March 24, 1906. The method of building in open sheeted caissons the concrete footings extending from bed rock to the grade of the lowest basement floor, of erecting the steel columns on the footings in these wells and then practically completing the superstructure of the building before the excavation for the basements and for the high and heavy concrete retaining walls around the latter had been made, was completely covered in that description. This same method has been followed generally in the construction of the remaining sections.

During the excavation in the caissons for the footings and of the three basements for section No. 1 some settlement occurred in the Champlain Building due to a flow of the clay under the latter into the excavation. Accordingly before any excavation was started for section No. 2, which immediately adjoins the Champlain Building the latter was carefully shored up and was held in position during the progress of work on that section and on section No. 3. The shoring is also still in place and will be left there until section No. 5 is completed, although that section will have one basement only, so its construction will not present any serious menace to the Champlain Building.

The steelwork of the latter has six transverse rows of columns, with five columns to a row, excepting the two rows next to section No. 2 which have four columns each. The row of columns in the end wall next to section No. 2 and the first row inside the building at that end were picked up from their footings by means of special clamps carried by a crib of heavy steel I-beams built up on screw planks on jack-screws resting on the old footings. The columns were held in their original positions by extending the jack-screws as the clay subsided under their footings during the progress of the work on the adjacent sections of the new building. When the latter is completed and the clay has ceased to sink under the Champlain Building new footings will doubtless be provided to replace the shoring and jack-screws which carry the end of the building. The mechanical plant of the building is in that end of the basement and when shoring operations were started the boilers of the plant had to be removed, but the machinery equipment has practically all remained continuously in service, steam being piped from the plant of a building across the street.

The center line of the last row of columns in the new building is 12 ft. from the wall line of the old building, the ends of the floor beams of the new building on that side being carried by the steel frame and by the walls of the old one. These columns are on usual circular concrete footings built up from the bed rock, 110 ft. below street grade. The excavation for these footings was completed in sheet caissons, the footings were brought up to the sub-basement floor level and the columns erected on them in the caissons before any other excavations had been made.

The concrete retaining wall along the side of section No. 2 of the new building has its face next to the old building about 12 ft. outside the wall line of the latter, the center line of the outside row of columns for the new building coinciding with the center line of the retaining wall. This retaining wall has a total height of 38 ft., extending from 4 ft. below the level of the lowest basement floor of the new building up to the floor line of the basement of the old building. It is 4 ft. wide at the top and 6 ft. wide at the bottom. The trench for this wall was made 6 ft. 4 in. wide, and had to be dug with exceeding care and heavily sheeted and braced to hold back the plastic clay under the heavy loads brought on it by the Champlain Building. The excavation for the trench was carried down the full width of the latter, 3 ft. at a time, and lined on each side as the excavation proceeded with 3-ft. lengths of 3x5-in. tongue and grooved lagging placed vertically. Two 6x8-in. waling pieces were placed horizontally on both sides of the trench for each 3-ft. length of lagging. The pairs of waling pieces at the same heights were braced against each other across the trench by 5-ton jack-screws, placed according to the span of the walings between the caissons that had been dug for the circular concrete column footings.

The retaining wall forms were then built up inside the lagging and the concrete carried up in layers about 1.5 ft. thick. The drums carrying the jack-screws were boxed in and left in place. Later as the excavation for the basement was completed the lagging on the front face of the wall and the drums carrying the jack-screws were removed. The boxing around the latter was also removed when the drums were taken out and the holes in the wall filled with concrete.

Practically all the shoring work on the Champlain Building was completed and all preparations made for holding the latter in place before operations had progressed far on the new building. Three of the columns in the row of four in the end wall were picked up and carried together on continuous shoring. These columns each carry between 650 and 700 tons. They are loaded so that some of the partially self-supported weight of the wall is transmitted to the shoring by them and the remainder directly. The column in this row on the street side of the building had to be carried separately, owing to a heavy steel box-girder that is cantilevered out from the column in the last row of the new building to support the lower end of a column which carries the corner of the tile and glass front of that structure.

The columns of the Champlain Building, with the exception of those carrying wind bracing, consist of two channels placed back to back and separated by a web formed by a plate and four angles, the general cross-section of the column being H-shaped. A grip is secured on each column close to the ceiling of the basement by a heavy special cast-steel clamp, the details of which are shown in an accompanying illustration. These clamps weigh about 2,000 lb. each and are made in two parts which fit together around the column so as to enclose the section of the latter on all sides. The two halves are machined to make a close fit and are bolted together with three 2-in. bolts on each side of the column. The load on the column is transferred to the clamp by six 2-in. round chrome steel bars 24 in. long, which are arranged in three pairs and pass through holes drilled in both halves of the clamp and in the web of column. The holes for two pairs of these bars are within the clamp, while the third pair take bearing on the top of clamp. The holes were all carefully made to an exact fit in order to cause all stresses to act in shear and to avoid bending moments. The space between the halves of the clamps and the columns were filled with cement grout to prevent any possibility of tilting.

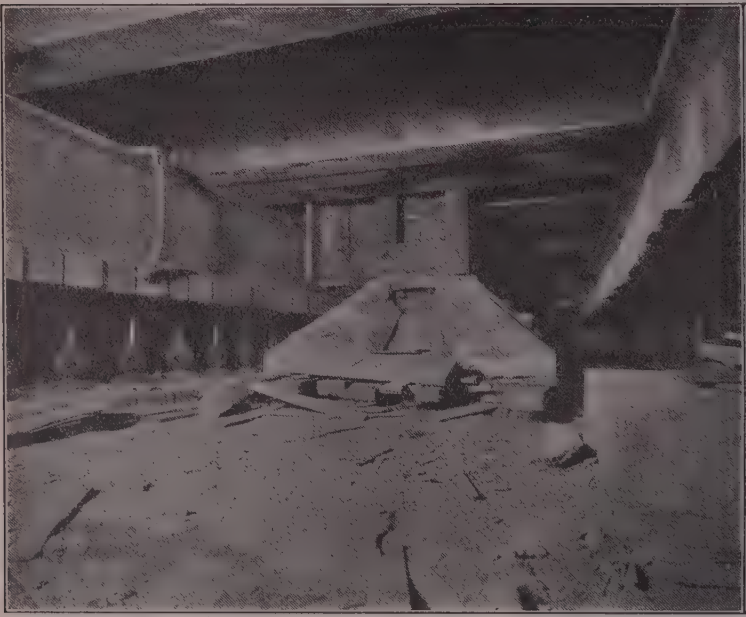
Each clamp is carried directly by four specially rolled 80-lb., 6-in. I-beams, 8 ft. long, and by two short sections of heavy steel castings having an I-shaped section. Two of the heavy I-beams are placed on each side of the column and under the clamp; one of the heavy steel castings is placed on each of the other two sides of the column between the pairs of I-beams. The castings and 6-in. beams are carried by two heavy special box girders, built up of two 15-in. I-beams and two plates. These girders are placed at right angles to the 6-in. beams, one on each side of the column. Both ends of the 6-in. beams are loaded through two I-beams carrying part of the load on the walls of the building, in order to partially counterbalance the loads at the centers of those beams brought on them by the clamp on the column.

The beams under the walls and the box-girders on which the 6-in. I-beams carrying the clamps on the four columns are set, rest on eight 100-lb., 24-in. I-beams, 60 ft. long, placed longitudinally under the wall in four pairs, two pairs in a set on each side. The two sets of pairs are placed with a span of 8 ft. between them to broaden the base of the shoring in order to secure additional bearing surface on the soil and to overcome any tendency of the shoring to tilt.

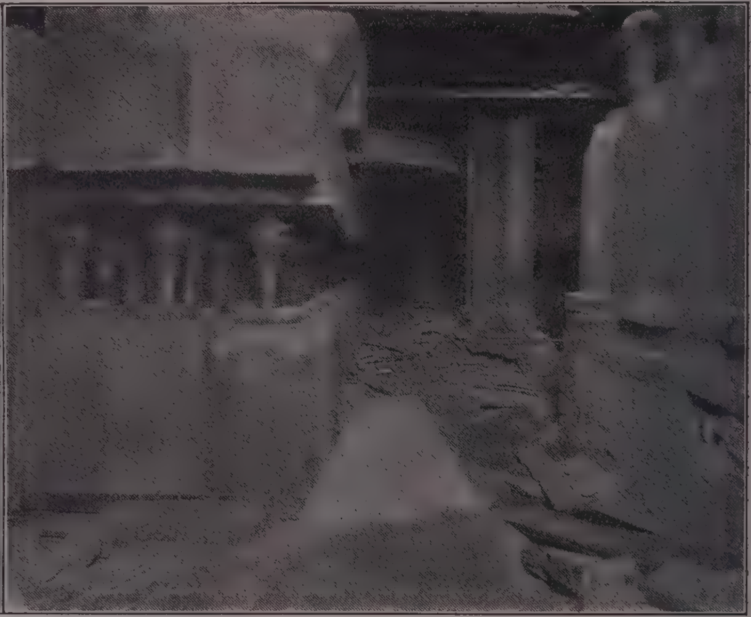
Each of the four pairs of 100-lb., 24-in. I-beams are carried by a row of 24-in., 50-ton jack-screws on 12x12-in. drums, 2 ft. long. The beams rested directly on 4x6-in. screw plank at first, but after the screw had been extended 6x6-in. blocks were placed over these plank. The drums of the jacks are on 6x6-in. timbers set on the old spread footings of the columns, which were built continuously. A part of the jacks and the continuous shoring under these three columns are shown in an accompanying view taken from the basement of the new building before the retaining wall had been completed. One of the columns for the new building and part of the sheeted well in which it was built may be seen in the immediate foreground. The long 24-in., 100-lb. I-beams carrying the beams and box-girders under the column clamps and the ends of those beams and girders may also be clearly seen.

A 5-ft. steel-plate smoke stack, which is 150 ft. high and brings a load of approximately 800 tons on its base, is in the corner of the rear of the buildings at that end, serving also as a column of the steel frame of the building. This stack was formerly carried by a steel shoe on a brick base built up on the basement floor. This brick base has been removed and the stack is supported entirely by shoring, pending the completion of the new building, the shoe being carried about 3.5 ft. above the floor. The stack is carried directly by twelve 20-in., 100-lb. I-beams which have been extended through it near the base. One end of these beams is carried by the shoring for three columns and the other end is carried by a nest of 25-ton jack-screws, placed in two sets of three rows each. The shoe on the base of the stack and the bases of two of the end row columns are shown in an accompanying illustration. The three rows of jack-screws on the left hand in the foreground of this view are one of the sets of screws under the outer ends of the 20-in., 100-lb. I-beams carrying the stack. At the time this photograph was made the footings of the columns had sunk over 6 in., and the blocks and wedges placed under the bases of the suspended columns are clearly visible.

The cantilever column support in the new building rendered the shoring of the first column in the end row of the old structure much more difficult than that provided for the other three columns of that row, owing to the limited space available. The same type of clamp was used in securing a grip on this column as was employed on the other three. The upper part of the shoring carrying the clamp was also arranged in the same manner as under the clamps on those columns. The head room being much more limited at this column, two rows of jack-screws were placed on each side of the shoring and about in line with the rows under the continuous shoring for the three columns. These jacks are inverted and were set without drums. Their heads stood on 3x6-in. oak plank laid on the spread footing of the column and their screws were passed through collars in 5x6-in. screw planks. The screw plank on each side of shoring were made long enough to extend over both rows of jack-screws. On these plank were set four 20-in., 80-lb., I-beams which were placed in two pairs, one pair over each row of jacks and the two beams of a pair placed just far enough apart to permit the screws to pass up between them. These beams were clamped in position by rods and held apart by spacing blocks. They carried directly the box-girders under the middle of the heavy 6-in.



Shoe on Base of 900-Ton Column Suspended above its Footing.



Shoe at Base of Stack and Bases of Two End Row Columns.

I-beams on which the column clamp rested, and also a pair of I-beams under each end of those heavy beams.

The columns in the second row were each loaded separately. Three of these columns carry loads of 600 tons each, while the other two are wind-braced against each other with heavy steel arches at each floor level in the building and carry loads of 900 tons apiece. The same general type of column clamp used in transmitting the loads from the columns in the end row to the shoring was also used in the second row of columns. The shoring for the two wind-braced columns was arranged much the same as that for the 650-ton column in the end row that was carried separately. The clamp was made to enclose the I-beam added on one side of the regular H section of the column to provide for the wind stresses. It rests on four 8-in., 100-lb. I-beams and on two of the short pieces of steel castings. These castings and the center of the 8-in. beams directly under the clamp are carried by two box-girders one on each side of the column. Both ends of the 8-in. beams are also carried by two 16-in., 80-lb. I-beams. The box-girders were loaded near both ends in order to partially balance the concentrated load on them at the middle. These girders and the four 16-in. beams are set on four pairs of 15-in., 75-lb. I-beams arranged at right angles to them in two sets of two pairs each, one set toward each end of the box-girders and 16-in. beams. These two sets of pairs of 15-in. beams are each carried by two rows of jack-screws which were placed with their heads down and their screws extending up between the two beams of a pair in the same manner that has been described for the 650-ton column shoring.

Part of Jackscrews and Continuous Shoring under the End Columns.

The two 600-ton columns in the second row were shored in a somewhat different manner as more space in proportion to their loading was available around them. The shoring is carried by four rows of jacks, two rows on each side. These jacks are on regular 12x12-in. drums, 20 in. long, and the rows are capped with 12x12-in. timbers. The drums are carried on 5x6-in. oak plank laid on the old footing of the column. The cap timbers carry the ends of the box-girders and beams on which the heavy beams and castings under the column clamp are set. Part of the load on the box-girders is also carried directly by ten 50-ton jack-screws immediately under the clamp on the column, five of these jacks being in a row on each side of the shoe of the column and bear on the old footing of the latter.

The building was considerably out of plumb at the time shoring operations were started, but thus far no endeavor has been made to do anything more than to prevent further settlement during the progress of the excavation for the new building basements and pending the completion of the retaining walls around the latter. This has been successfully accomplished, although the footings for the columns in the end row have gone down about 7 in., and those in the next row about 6 in. since the adjacent excavations were started. The columns and walls have been held to their original elevations while this settlement was taking place by gradually extending the 3,500 jack-screws that carry the shoring on which they rest.

A tendency for the footings of the columns adjacent to the deep excavations to slide toward the latter would doubtless have been evidenced if precautions had not been taken to prevent such action. The footings for the end row of columns were anchored back to the columns in the transverse row at the other end of the building by five 2-in. steel rods. Two I-beams were laid horizontally on the first off-set on the trench side of the footings for the row next to the excavation and were bolted together with a separating block between them so the 2-in. rods could pass through the opening. A washer and a nut were placed on the end of each rod and a turnbuckle was inserted in the latter every 20 ft. The rods were anchored to the columns at the front of the building by pairs of I-beams placed 2 ft. above the finished floor. The shoring was set on the footings of the columns and the base of the whole building thus held together.

The merchandising business on the first six floors of the Champlain Building has been carried on and the offices in the remaining floors have been open without any interruption since shoring operations were started. In fact, the shoring was all done without any evidence on the street that it was in progress, the sidewalk having been kept continually open for traffic. With one exception the heavy plate glass windows in the building have not been cracked.

The shoring that was required under the Champlain Building and also that under other buildings in the vicinity of the deep excavations is being done by L. P. Friestedt & Co., building raising and moving engineers, of Chicago. Messrs. Holabird & Roche, of Chicago, are the architects for the new building.

Dry and Wet Excavating.

At a recent meeting of the Society of Arts, M. Philippe Bunau-Varilla read a paper on the Panama Canal, which brought out an interesting discussion on the relative advantages of different methods of carrying on large amounts of excavation. The chairman, Sir John Wolfe-Barry, stated his approval of dredging rather than dry excavation for canal work. The broad principle commended itself to an engineer at once, that if it was possible to use the flotation power of water to bring the excavators to the place where the excavation had to be made, and if it was also possible to take the barges from the dredger to the place for which they were destined, it would solve some of the greatest difficulties of dealing with such a work in such a country. Instead of treating great rainfall as an enemy, this plan converted it into a friend and an ally. His own experience went to corroborate these views entirely, because he very well knew the cost of excavating in waterlogged strata when the excavation was made in the dry, where the rain caused innumerable slips of earthwork and occasioned the greatest difficulty in maintaining the roads. If these difficulties could be avoided, an enormous amount of trouble was done away with, and a price was reached which was far and away less than anything which could be contemplated for excavation in the dry.

He supposed one might almost say that the Suez Canal would have been impossible of construction if it had not been for the great improvement in dredging plant which took place about the time that the problem had to be undertaken, although in that instance the distances to which the earth had to be transported were comparatively short. Since that time the development of dredging plant had gone on by leaps and bounds, and engineers were now able to use dredgers supported by water at the spot where the work had to be done, of a power and celerity of excavation which were never dreamed of in former years. All those developments had taken place within the memory of those present, and they were not yet at an end.

He had had something to do with the Suez Canal, and could speak from experience with regard to the question of the excavation of rock under water. Mr. Quellennec, the consulting engineer of the canal, knew the price of the work much better than he did, but the matter was brought before him while he was a member of the International Consultation Commission on the Suez Canal. It was at one time considered that the excavation of the rock between the Bitter Lakes and Suez for the purpose of deepening the canal to suit the modern requirements of ships presented such a serious obstacle that the work was suspended for many years, although everybody knew it would have to be done. But that difficulty disappeared. The work was done without explosives, the traffic of the canal was not interrupted, and the price at which the excavation of the rock under water was done was given by Mr. Quellennec at 1s. a yard. Mr. Hunter had also stated that he excavated the rock in the Manchester Canal under water by the same Lobnitz process at 9d. per cubic yard; and those prices engineers must take as facts.

Progress of Construction on the Riverside Drive, New York.

Riverside Drive, New York, is a wide boulevard flanked with bridle paths, sidewalks, lawns and shrubbery which winds along the east shore of the Hudson River northerly from its commencement at 72d St. It is laid out with numerous curves partially following the contours and affording many graceful sweeps and varied perspectives of the beautiful river, handsome buildings and parks and maintains a varying elevation of 20 to 90 ft. above the water, with maximum grades of about 2 per cent.

Its construction was commenced at the southern extremity, where a section about two miles long was completed nearly 20 years ago. It is proposed to extend the drive eventually several miles up the river to Spuyten Duyvil and contracts for sections 2, 3 and 4, reaching from 135th St., about 1½ miles to 158th St., were awarded in 1904 for a total price of about $3,200,000, and have now been virtually completed, so far as the masonry excavation and filling are concerned, and are receiving the final work on the roadway, sidewalk, sodding, planting and pipe laying included in an additional appropriation of about $700,000. The details of construction and the contractors' methods and plant have been illustrated in The Engineering Record of Feb. 11, March 25 and April 15, 1905, and Sept. 15, 1906.

A total amount of about 750,000 cu. yd. of masonry of all classes has been laid and 300,000 cu. yd. of materials have been excavated and about 370,000 yd. of fill have been made with a system of mast and boom derricks extending the full length of the work and served by standard gauge tracks parallel with the river and operated in one case by cables and in the other by locomotives. One concrete plant was installed on shore adjacent to the power house at the south end of the work, and supplies were delivered to it from the dock about 350 ft. distant and 50 ft. lower down, by a 30-in. Robins belt conveyor operated by an independent steam engine. At the north end of the work, concrete was mixed in a floating plant. On section 2, 22 of the 26 derricks and most of the movable plant have been taken away but the power plant at 139th St., the concrete plant and the conveyor plant have not yet been displaced, although only the conveyor and the four remaining derricks are now in actual service. None of the plant on sections 3 and 4 has yet been removed.

The construction in general is an earth fill up to 60 ft. deep between two parallel retaining walls from 150 to 250 ft. apart. The east wall will be backfilled on the outside by future grading and building operations and is therefore made of rubble masonry. The west wall, on the river front, is very conspicuous from the water and from the street and railroad at its foot, and is built of granite, rock-faced ashlar masonry with very large uniform stones.

Some of the principal intersecting streets pass under the speedway through archways which, with the buttresses, stairways, balconies and other features of the work, together with the wide panels relieving the front wall and the effect of the cut stone quoins, coping and balustrade for the massive masonry, present an impressive appearance very satisfactory in a monumental work of this character and reflecting credit on the engineer, the architect and the contractor alike, all of whom have worked in harmony to secure the best quality and appearance of the structures.

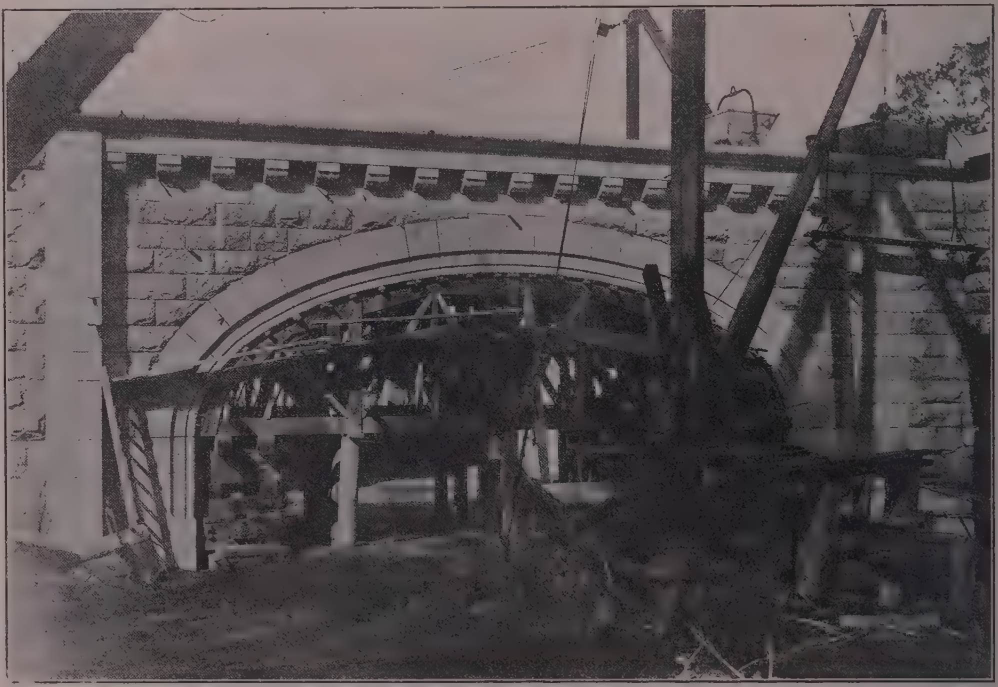
A large portion of the fill was provided by the spoil from the excavation for the adjacent portion of the rapid transit subway, and was delivered in cars lowered down the steepest of the intersecting streets by hoisting engines and cables which also served to haul the empty cars back again. Care was taken not to dump an unnecessary amount of material over the sites of the foundations, and when the excavations were made they were in many cases outside the slopes or intersected them below the top. As much of the fill had remained in position for one or two years, it was well solidified and trenches were easily excavated and sheeted through it for the foundations of the east wall, which has an average height of about 20 ft.

The construction of this wall was commenced simultaneously at several points, usually selected where little excavation was necessary for the foundations. As the work progressed, the excavation often increased and work was maintained at such a rate that the spoil removed in scale boxes from the advance trench could be dumped as backfill on the adjacent completed section of the wall without rehandling, being handled entirely by the derrick with which it was hoisted or in some cases being passed from this derrick to an adjacent one by which it was dumped. Usually the distance between the open trench in which foundation work was not yet commenced to a point where the masonry and backfilling were completed did not exceed 400 ft., and was commanded by four stiff-leg derricks, with 10-ton 65-ft. booms. As fast as the work progressed, the rear derrick was removed from the completed structure and set up in advance for excavating the foundation trench.

The slopes of the original fill did not extend over the foundations for the retaining walls, and after the latter were built, the wide triangular spaces behind them with a maximum height of 70 ft. were backfilled with earth and stone dumped from carts on top of the bank. Weep holes through the feet of the walls communicate with a 2-ft. layer of loose stones piled up on the back side to provide drainage for water.

Much backfilling was done during a season of heavy rains, and the contractors took pains to utilize the storm water to consolidate the loose earth. On many occasions the catch-basin inlets at the feet of the steep transverse streets were temporarily closed so that the storm water in the gutters could not escape to the sewers and was led over the embankment through ditches cut as required and often divided into several branches to distribute the flow to various points of the fill. Considerable streams of water were thus discharged over the loose earth, and care having been taken to protect the open trench at the foot of the retaining wall, it was obliged to soak through the main embankment and washed fine material into all of its cavities, thus thoroughly compacting and settling the earth and considerably expediting the time when paving could be commenced without danger of serious settlement.

Although the curves and grades of the roadway and sidewalk were very carefully and accurately given on the maps and profiles, the relation of horizontal and vertical changes in alignment is so difficult to present in a single projection that many places required revision when the work was constructed. Curves and grades that were smooth and satisfactory on the plans became unduly prominent when constructed and could only be rectified by repeated trials, cutting and easing them until a satisfactory appearance was secured.



One of the Arches on the Riverside Drive Extension.

The determination of the time for paving and curbing was a rather difficult matter, because, on the one hand, if the work was done too soon farther settlement would necessitate extra expense either in raising it, or if too much allowance for settlement had been made, in cutting it down; while on the other hand, a long delay in waiting for permanent conditions of the fill caused a loss to the contractors by deferring the final payment on the work. In order to hasten and assure the settlement, a large quantity of telford stone for the roadway was stored on the fill adjacent to the east wall. About 10,000 cu. yd. of this stone was received during the last two years from excavations in the vicinity and was deposited in piles from 12 to 14 ft. high and 25 ft. wide covering the full width of the sidewalk area. Its weight was sufficient to compress the material so that the curb could be safely set there as soon as the stone was removed.

The surface of the roadway was very carefully dressed to sub-grade and rolled with two 10-ton Buffalo Pitts steam rollers, which sometimes completed the work in two or three trips and seldom worked more than one day each on a section 200 ft. long. As the rolling progressed 1 or 2 in. of clean earth was spread wherever required to level up the surface to the required profile, and the rolling was continued until the earth ceased to rise in waves in front of the rollers.

The space between the curbs is covered with a layer of 12-in. telford stone, the tops of which are knocked off with spawling hammers and the spaces filled with chips and spawls, and it was rolled to a regular thickness of 10 in. It is covered with 1½-in. trap rock thoroughly rolled, over which the final layer of Roa Hook gravel is rolled and sprinkled to make the finished surface. Road making was commenced in the fall of 1906 with a force of about fifteen men, who were thoroughly trained with a view to educating them enough so that next spring they may be divided into several groups forming the nuclei of a number of gangs which will be able to carry on the work rapidly and efficiently as soon as the weather permits.

Grade marks are established on the slopes at intervals of 10 or 15 ft. and the surface is dressed to them by hand with shovels, the upper layer of loam being very easily distributed and the surface easily inspected by the eye. Road making materials, loam, and other supplies for sections 2 and 3 are delivered to the contractors' pier and thence elevated to the top of the bank by the Robins belt conveyor, which deposits them in hopper bottom bins from which they are discharged by gravity to cars and wagons and distributed along the line. The belt conveyor being operated by a separate engine is independent of the power plant, and being elevated above the ground can be maintained until the grading, sodding and road making under it are entirely completed.

Two Views of Masonry Wall and Special Construction on Water-Front Side of Riverside Drive.

A curious and unexpected condition was observed at 135th St. where the new work adjoins that of the section completed several years ago. Here the west wall has a height of 75 ft. and the excavation for it by the contractor for the older section was very difficult and expensive on account of a bed of quicksand encountered just above the level of the foundations and a few feet below ground water level. The material was very soft and slimy and, being excavated in an open trench, sloped back a great distance from the river at a very flat angle necessitating a great amount of excavation, which was made with a steam shovel.

Subsequent to the completion of this work a large amount of fill has been made on the original surface and when excavation was made through it for the present work and the quicksand below was encountered, the contractor made advance preparations for such difficulties as his predecessor had experienced, purchasing large quantities of very heavy sheet piling and powerful pumps to drain the trench. The excavation was carried down to water line and several well points, protected by wire netting, were driven in the bottom and coupled up to the pumps.

About 1,000 piles were required in the trench, 56 ft. wide and 108 ft. long and, much to the contractor's surprise, they were driven with great difficulty and could not be made to penetrate more than about 10 or 12 ft., although those driven previously in the older work had penetrated up to 40 ft. After the piles were driven, the trench was pumped out and excavation was commenced and carried down 2 ft. without sheeting or continued pumping and without any difficulty. The sides of the excavation stood well, although if a shovelful of material was struck once or twice it would flow several feet and manifest all the qualities of extremely quick sand. This change in the character of foundations in a few years is very unusual.

Mr. F. Stuart Williamson is the consulting engineer and designer, Mr. William Tyson Gooch is the consulting architect, and the Ryan-Parker Construction Co. and J. C. Rodgers & Son, are the general contractors.

The Reinforced-Concrete Cathedral of St. Mary and St. John, at Manila, is especially noteworthy because, from a material not generally considered suitable for church architecture, a structure of much beauty has been evolved by following the dignified lines of the Spanish Renaissance, used in the old missions of California. Reinforced-concrete was used mainly because it is considered proof against earthquakes, white ants and dry rot, three destructive agencies common in the Philippine Islands. The edifice is cruciform, with a dome, and towers on either side of the main entrance. The main part is 60x180 ft. in plan over all, and the wings are 22 ft. long and 18 ft. wide. The dome is octagonal in plan, 50 ft. in diameter and 76 ft. high. The towers are 18x18 ft. and 57 ft. high. The building has a seating capacity of 1,000 persons and cost about $100,000. The foundation rests on piles and is a solid wall up to the water-table, above which two 6 to 8-in. walls are used with an air space of a foot or more between them. Round mild-steel rods are used for reinforcement. The structure was designed by Messrs. Sturgis & Barton, of Boston, constructed by the Atlantic Gulf & Pacific Co., and is the gift of Mrs. Mary Bryant Brandegee, of Brookline, Mass.

Erection of the Girard Trust Company's Building, Philadelphia.

The Girard Trust Company's 140x140-ft. building on Chestnut St., Philadelphia, is about 115 ft. in extreme height and contains a rotunda 82 ft. square surmounted by a dome over the main banking room, surrounding which are various other rooms and offices all devoted to the use of the company. The dome and part of the roof and floors are supported on eleven interior steel columns. All of the remainder of the structure is built with Blue Ridge marble from Nelson, Ga., and contains many very large stones, the heaviest being the 3x5x18-ft. lintels and the 6-ft. sections of sixteen solid columns 4 ft. 9 in. in diameter.

In order to handle the material to the best advantage, the contractors commenced operations by the erection of a tower 81 ft. high and 64 ft. square over all, which was located in the center of the corridor and was equipped with three derricks together commanding the entire area of the building and sufficing to unload all materials from the trucks on which it is delivered in either of the two streets on which the building fronts, and to place them in temporary storage or set them in position as required for the erection of the building. The tower really consists of four separate towers symmetrically arranged in the corners and braced together by horizontal trusses in the planes of the exterior faces at the upper ends and in the middles of the small towers. Excepting the vertical tie rods in bracing trusses, the tower is made entirely of timber.

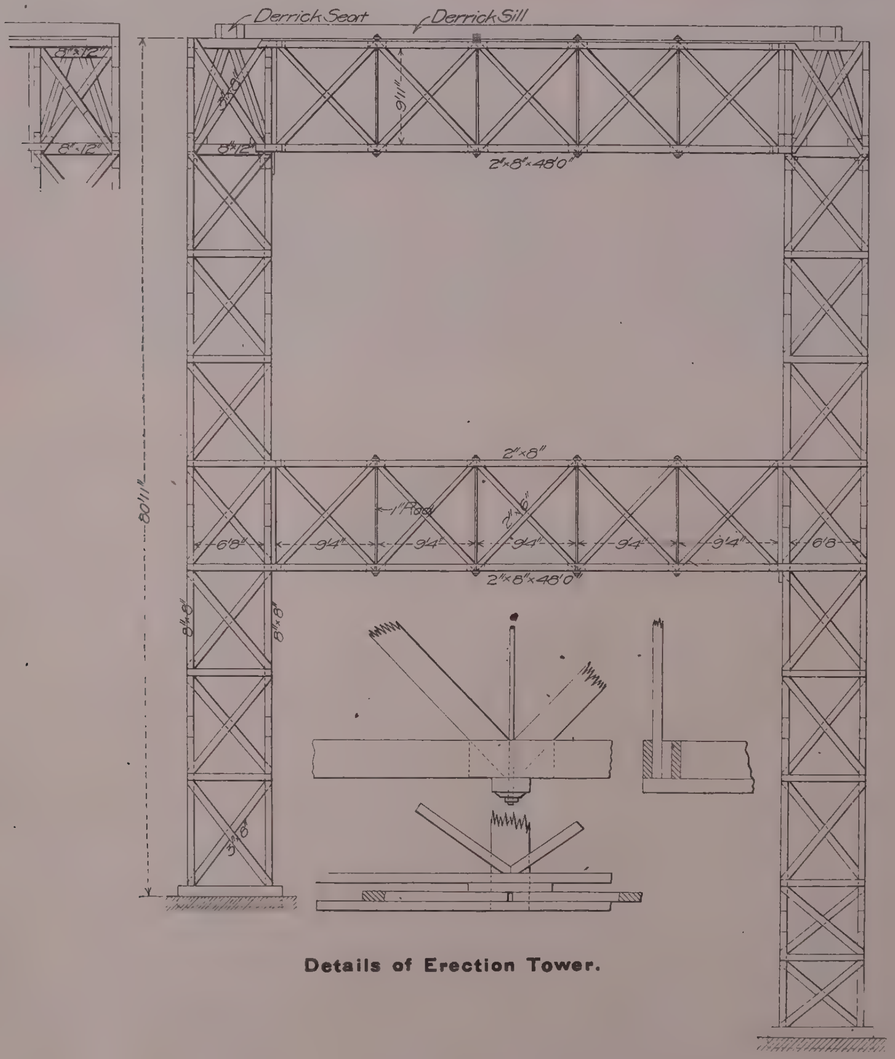
Each small tower, 8 ft. square, has four 8x8-in. vertical posts one at each corner which are built with sections about 20 ft. long spliced with butt joints and cover plates in the middles of the alternate panels formed by 3x8-in. horizontal braces bolted across each face of the tower. The panels are X-braced with 3x8-in. diagonals and the lower ends of the vertical posts are seated on 12x12-in. sills 10 ft. long. The upper ends of the towers are connected by Howe trusses 10½ ft. deep over all with their top and bottom chords made with pairs of full length 2x8-in. planks projecting at the ends to form jaws engaging the vertical posts and horizontal struts in the tower and thoroughly bolted to them.

The diagonal members of the trusses are made with 2x6-in. planks with their ends beveled vertical to bear against each other and secured without angle blocks by bolts through the chord planks, between which they are held by the shearing and bearing value of the bolts and by the friction developed. These trusses are built in pairs, in the planes of both faces of the tower, and are braced together by 2x8-in. X-braces in the planes of the top and bottom chords. They are placed with their 8-in. dimensions vertical and have their ends beveled to bear against each other and against the chords. They are set with their upper and lower edges flush and are notched to clear each other at intersections. The lower horizontal trusses are similar to the upper ones except that the ends of the chords butt against the inner faces of the tower posts and are bolted to the ends of the 3x8-in. tower struts, one of which projects across the post to receive each chord.

The transverse caps in the tower tops are 8x12-in. timbers seated on the upper ends of the posts and secured to them by wooden scabs. These carry at the center pairs of 8x12-in. sills reaching across the full width of the tower on the center lines of the trusses which support them by transverse beams at panel points of the top chords. These sills are thoroughly bolted to the tower and are pin-connected through steel bearing plates bolted on both sides to the 16x16-in. stiff legs of derricks seated on the centers of three corner towers.

The derricks have 18x18-in. masts 45 ft. high and 16x18-in. booms 65 ft. long, rigged with four-part wire rope hoisting and topping tackles operated by Mead-Morrison electric hoists seated on a platform carried by beams and stringers supported on the top chords of the upper trusses of the tower. The upper panels of the corner towers are provided with extra 8x8-in. diagonal bracing to stiffen them and transmit the derrick load to the corner posts at the level of the lower chords of the horizontal trusses.

Progress View at Girard Trust Building.



Details of Erection Tower.

As the tower is located on the dome center and clears all of the wall and floor construction of the building, it can handle all parts of erection except that of the dome, which will not be erected until after the removal of the tower. It is built of commercial sizes of timber which, excepting the ends of the diagonal bracing plank, are cut square and are not injured by framing, so that they are available for other construction and have a considerable salvage value. The tower has been in operation over a year and shows great stability under wind pressure and absence of vibration even when the derricks are all rapidly handling heavy loads.

Mr. Allen Evans, of Philadelphia, and McKim, Meade & White, of New York, are the architects of the building. William Gay & Sons, Philadelphia, are the general contractors and the steel beams and columns are furnished by the Cambria Steel Co.

A Very Large Dredge has been built for the Indian government by W. Simons & Co. It is of the hydraulic type, 250 ft. long, 45 ft. wide and 18 ft. deep. Its length is 250 ft., beam 45 ft. and depth 18 ft.; it has three complete bows, thus forming for a length of about 35 ft. back, two open wells each about 8 ft. 6 in. wide. A framework in each of these carries a length of suction piping, to each of which are attached two nozzles; also shafting and gear for two rotary cutters arranged to work in advance of the suction nozzles for disengaging the clayey material which would otherwise be unsuitable for suction-pump dredging. Each suction-frame is also provided with a system of water-jets delivered under high pressure for agitating compact sand not requiring the rotary cutters. Water for the jets is supplied by two special centrifugal pumps in series, driven by an enclosed high-speed compound engine. Each pair of cutters is driven by bevel and spur gear from an independent four-cylinder tandem compound engine placed on deck at the edge of the wells. The two centrifugal sand suction-pumps, situated a little forward of midship, have a nominal dredging capacity of 4,000 tons of sand per hour from a depth of 20 ft., and are specially constructed with wide spaces to admit the passage of large pieces of débris. Each suction-pump is driven by an independent set of vertical triple-expansion engines of 900 I.H.P.

THE CONSTRUCTION OF THE CHIHUAHUA & PACIFIC RAILROAD.

By F. Lavis, M. Am. Soc. C. E., Resident Engineer, Pennsylvania R. R. Tunnel, Hoboken.

There was, and to a certain extent still is, a general impression in Europe, or at least in Great Britain, that most of the railways in the United States are apt to be rather poorly built and of more or less flimsy and gingerbread construction, as compared with those in that country, and a similar impression exists in the United States in regard to the countries to the south of us. This was forcibly illustrated in one case where a man in applying for a position in the Eastern United States, citing certain experience in South and Central America, was met by the remark of the prospective employer: "Well, you know, there are lots of men who have been chief engineers in South America who couldn't fill rodmen's places up here."

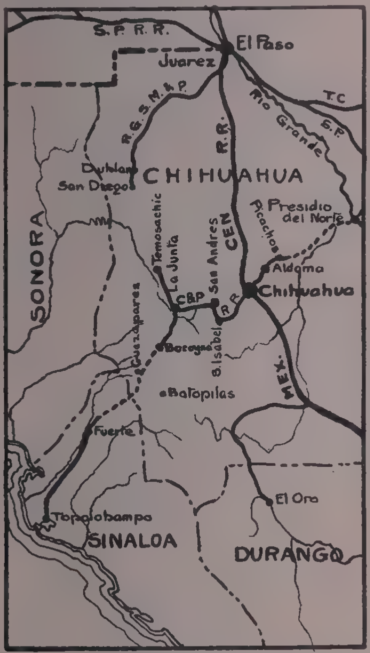


Fig. 1. North Mexican Railways.

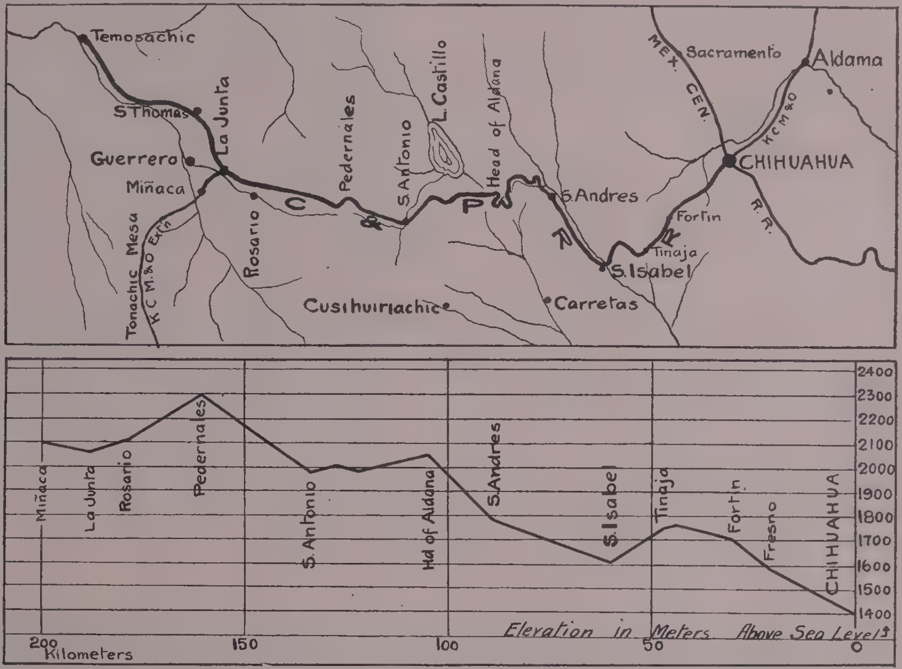


Fig. 2. Map and Profile of the Chihuahua & Pacific Railroad.

The Chihuahua & Pacific R. R. affords an example by no means rare of the type of construction of the better class of railroad in the Latin-American countries, but especially in Mexico, Chili, Peru and the Argentine, and to a lesser extent in the other countries. It is felt by the writer that probably on account of a fancied difficulty in obtaining engineers, which is, after all, usually only a question of salary, that as much attention is not paid to the saving in construction as well as in operation and maintenance possible by a proper location as is desirable; but the actual construction will compare favorably with the greater part of the railroads which have been built in this country.

The Chihuahua & Pacific R. R., as shown on the accompanying map, Fig. 1, runs westerly from Chihuahua, the first large city in Northern Mexico on the line of the Mexican Central Ry., south of Juarez and El Paso on the border. It is a standard-gauge line of which the first 200 kilometers (124.3 miles) from Chihuahua to Miñaca was built in 1898-9 under a subsidy from the Mexican government, for it is expected that this line will eventually be extended to the Western Coast, to enable that part of the Republic now virtually cut off by the Sierra Madre to be brought under more direct control of the central government. An extension of 88 kilometers (54.7 miles), was built in 1905-6 northwesterly from La Junta to Temosachic to reach the timber lands, and from this latter point the Greene Consolidated Mining Co. has built a line 53 kilometers further to San Pedro.

Prior to the construction of the Chihuahua & Pacific R. R., all the supplies for the large and growing mining districts of that part of the Sierra Madre, which are now tributary to it, were freighted in wagons to Guerrero and other points, whence they were packed on mules and burros into the mountains. The western terminus of the first section is within a few miles of Guerrero, which was the general distributing point for the Jesus Maria, Pinos Altos and other mining districts in that vicinity and the terminus of the wagon road from Chihuahua; it was expected that this wagon traffic would form the basis of the freight business of the Chihuahua & Pacific R. R. As is often the case, the builders of the road, after construction was well started, sent down from New York representatives to investigate the traffic possibilities, who found that the long lines of freight wagons which had filled the eye of the original protomers didn't look nearly as large when their capacity was figured as train loads, and the outlook for enough paying business was not considered very bright. It is quite possible that had their report been received before construction was started, the road would not have been built by their employers, and what has since proved, as shown partly by the building of the Temosachie extension and several enlargements of the terminal facilities at Chihuahua, a very profitable venture for the owners, would have fallen into other hands. As is generally the case, the supply of transportation facilities has created a steady increase in the demand since the day the road was opened, all of which goes to show the necessity of wide experience as well as a certain amount of imagination and foresight in estimating the probable future traffic of a road, from the cold, bare facts available before it is built.

In general it may be said that railroads running approximately north and south through Mexico, at least north of the capital, and parallel with the mountain ranges, find comparatively easy construction for most of their length, while those running east and west from the central backbone to either coast find almost insurmountable difficulties, at least from a practical commercial standpoint, in crossing the various ranges and in descending to the coast. The Tampico and Vera Cruz Rys. are familiar examples of the difficulties encountered on the easterly side, while these latter have been so great on the western side that no road has as yet reached the coast, although several are projected and parts of them are being constructed.

In granting the subsidy noted above, the Mexican government has pursued a policy of encouraging, in every way possible, the construction of lines of communication with the Western Coast, and it is intended that the C. & P. R. R. shall form part of this scheme; the concession for the remainder of the line from the western terminus of the C. P. at Miñaca to the coast is in the hands of the Kansas City, Mexico & Orient Ry. which proposes to build a line from Kansas City southwesterly through Oklahoma and Texas to Presidio del Norte on the border and thence via Chihuahua and the C. & P. R. R. to Topolobampo Bay. A part of this line is now built and in operation in Kansas, 125 kilometers has been built across the plain easterly from Chihuahua to Picacho via Aldama, 102 kilometers southwesterly from Miñaca to Bocoyna at the edge of the Sierra Madre and part of the line from Topolobampo Bay easterly to Fuerte.

The following description applies only to the work on the first section of the Chihuahua & Pacific R. R., though the second section is believed to be equally well built with the exception that a location closer to the timber districts permitted the construction of a few wooden bridges.

Owing to the absence of suitable timber anywhere near the proposed line and the cost of importing timber from the United States, it was decided at the outset that no wooden structures should be used; all culverts were of masonry, and all other openings steel spans resting on masonry abutments. Even the foundations of the water tanks at the stations and elsewhere were of ashlar masonry, the cost of which was found to vary so little from that of a wooden or steel support that, taking into consideration the permanence of the structures, the masonry was considered most economical and probably not of the greatest first cost.

The stone used for the masonry in all but a few cases was a porphyry, in appearance like a fine-grained gray sandstone, and was known locally as "cantara." When first quarried, the stone is quite soft and can be very easily worked, but hardens under exposure to the air, and has good weathering qualities, as shown in the cathedral and other buildings in Chihuahua where a

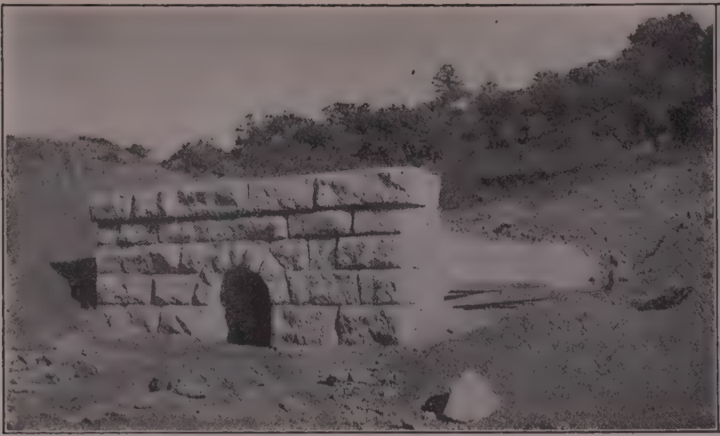


Fig. 3, 1-Meter Arch Culvert and End Wall.

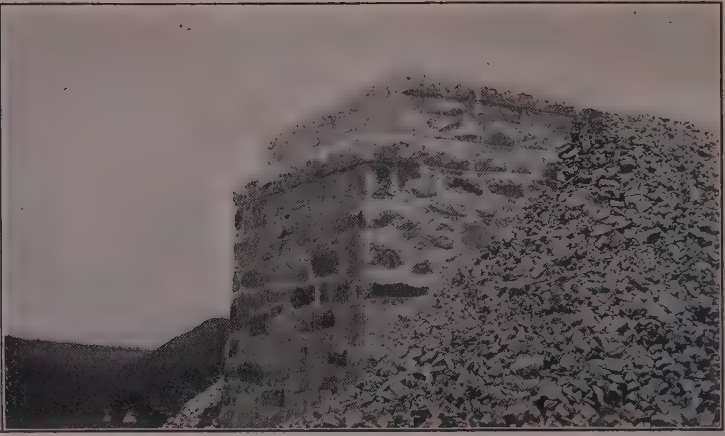


Fig. 6, Rubble Masonry U-Abutment.

great deal of fine carving has withstood the action of the elements for many years. In a few instances a hard volcanic tufa something like granite in appearance was found, and one pair of ashlar abutments was built of this and three of the eight U-abutments for the Aldana viaducts were built of rubble masonry of this stone, as shown in Fig. 6.

All the masonry except the bridge seat stones was laid in a very excellent quality of lime mortar. Portland cement cost something over $5 gold per barrel delivered in Chihuahua, and its use on an extensive scale was therefore out of the question. It was found necessary, however, to set the bridge seats in Portland cement, as the lime mortar, being very slow setting, allowed several of them to crack when the bridges were set on them, and they received the weight of the trains. In the course of construction, it became necessary to remove several old abutments of masonry laid in lime mortar, which had been built some twenty years or so previously, when an attempt had been made to build the road, which failed for lack of money, and in many cases it was found that stones had been broken across a mortar joint of lime by the blasting which was necessary to remove these abutments, thus showing the good cementing quality of the lime.

The steel bridges were of I-beams for the smaller openings 2, 3 and 4 meters, and plate girders for other openings up to 25 meters; standard lengths, which were invariably used, being 6, 8, 10, 12, 16, 20, 25 meters. Two trusses were built, one at Sta. Isabel over the Sta. Isabel River, and the other at El Carpio over the Guerrero River. Besides these there were four viaducts in the Aldana Cañon, the dimensions of which are shown in the table.

All the bridges were designed and built by the Pencoyd Steel Co. under the general inspection of Messrs. Hidreth & Co., of New York.

Pictures of two of the viaducts are shown in Figs. 7 and 8, and one of the U abutments built of rubble masonry in Fig. 6. The capstones for the pedestals supporting the bents of these viaducts were of the hard volcanic tufa previously referred to and were set in Portland cement. The bridges were erected by men furnished by the Pencoyd Co., working under the direction of the chief engineer and employed directly by the railroad company.

The smaller openings where culverts could be built were generally arched on account of the difficulty of obtaining suitable cover stones. Fig. 3 shows a typical 1-meter arch and Fig. 4 a 3-meter segmental arch. Fig. 5 shows a typical pair of ashlar masonry abutments for one of the smaller openings, the abutments for the larger spans differing only in dimensions. Wing abutments with the wings at an angle of 30 deg. with the line of the main abutment were used altogether, except in the case of the Aldana viaducts where U-abutments were built. The average cost of these latter per pair was about $5,000 Mexican currency, while the pedestals averaged about $200 each.

VIADUCTS IN THE ALDANA CAÑON.

No.	Length.	Highest	No. bents.	Alignment.	Grade.
1	414 ft.	63 ft.	13	Tangent	2%
2	430	79	13	Tangent	2%
3	506	69	16	12° curve	1.44%
4	299	63	9	12° curve	1.44%

Native labor was used almost entirely in building the masonry and was found entirely satisfactory. An attempt was made to bring in masons from the United States, but the results attained did not warrant the higher wages which the American masons were paid over those paid to the natives.

The only other structures of interest were two short tunnels in the Cañon of the Sta. Isabel River just below San Andres, one of which is shown in Fig. 9.

The track was laid with a Harris track-laying machine, with 60-lb. rails and hard pine ties. About half of the ties used in the original construction were imported from Texas, the remainder being native ties, cut within wagon-hauling distance of the line. Since the completion of the construction of the road, a rock-crushing plant with a No. 6 Gates crusher has been installed near the lower end of the Aldana Cañon and the entire line is being gradually rock ballasted, about 50 per cent. being now finished. Native ties are now being used exclusively and are treated at the company's plant at El Carpio (La Junta) by the Wellhouse process with a solution of zinc chloride, glue and tannin. The width of roadbed at subgrade was 4.3 m. (14.1 ft.) for embankments, and 5.8 m. (19.0 ft.) in cuttings.

The map and profile, Fig. 2, will show in a general way the physical features of the road, where stretches of rough country necessitating considerable curvature and quite heavy work alternated with stretches of prairie where long tangents and light scraper work were the rule. This favored the letting of the work to a large number of sub-contractors with small outfits, who could be distributed over the line to points where they could work to the best advantage. On the descent from Tinaja to the Sta. Isabel valley, there was a stretch of quite heavy work as also from kil. 80 to kil. 105, through the cañon of the Sta. Isabel River and the Aldana cañon, which latter section was the heaviest on the line, the amount of excavation, which was mostly rock, averaging about 18,000 cu. m. per kilometer (30,000 cu. yd. per mile). On this section were the two tunnels and four viaducts previously mentioned.

Grades of 2 per cent., compensated for curvature (0.07 per degree metric = about 0.04 per degree 100 ft. chords) were used going west, and 1.8 per cent. going east. The longest stretch of 2 per cent. grade with practically no break, was between San Andres and the Head of the Aldana, a distance of about 15 kils. The sharpest curves were 8° metric (about 12° American), which were confined to the Aldana cañon, where there was one with a central angle slightly less than 180°, and one slightly over that amount.

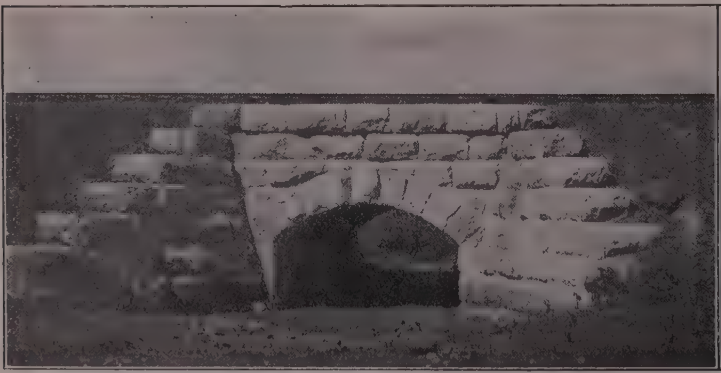


Fig. 4, 3-Meter Segmental Arch Culvert.

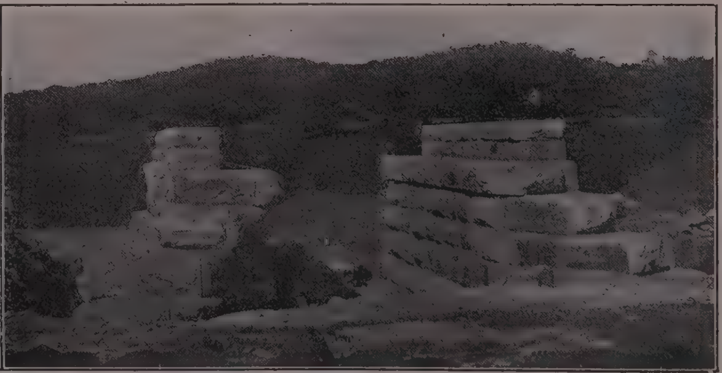


Fig. 5, Typical Masonry Bridge Abutments.

The contract for the whole of the construction was let to a firm of American contractors, who gave it up after only a small amount of work had been done. The work was then carried on by the company under the direction of Mr. R. Dudley, as superintendent of construction, the sub-contractors being retained on their work The masonry for the first 90 kils. was completed by the company forces after the work was abandoned by the original contractor, except for a small portion between kil. 40 and kil 60, built by Jos. Qualey, who also built the abutments for the viaducts. The masonry on the last 100 kils. was built by Wm. O'Gara, under contract with the company.

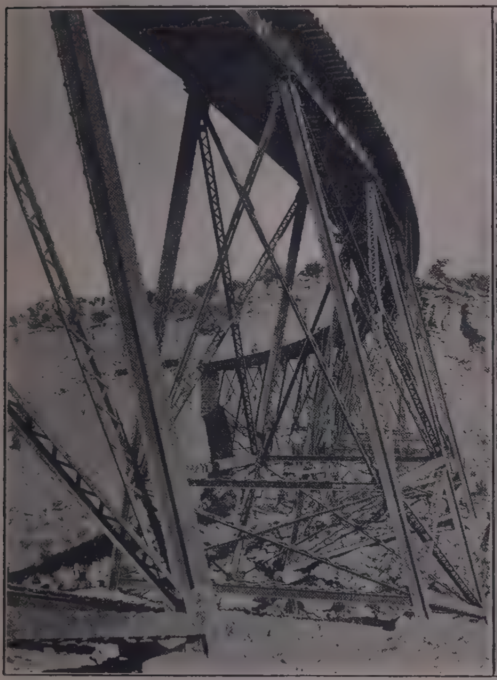


Fig. 8, Viaduct No. 3.

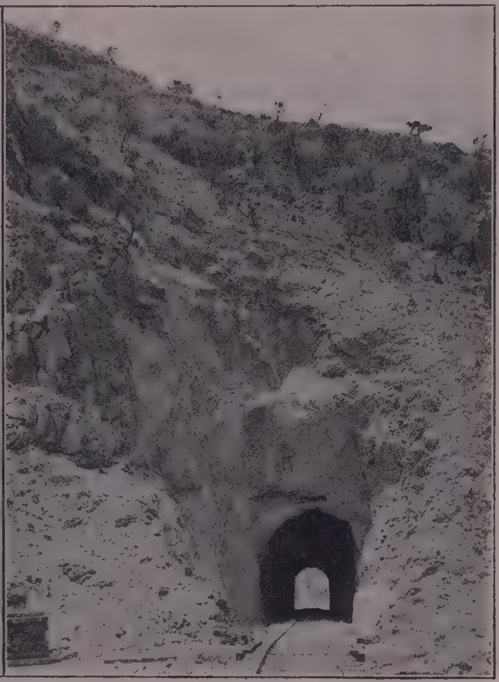


Fig. 9, Tunnel No 1.

The cost of the work varied on different portions, but the following is considered a fair average for the whole work, prices being in Mexican currency, $2.20 Mex. = $1.00 gold: Grubbing and cleaning, 1 cent per square meter; solid rock excavation, $1.30 per cubic meter; loose rock excavation, 65 cents; hard pan excavation, 40 cents; earth excavation, 22 cents; overhaul, 5 cents per cubic meter per 20 m. in excess of 150 m.; masonry, first class, laid in lime mortar, including all dimension stone, used as arch sheeting, coping, bridge seats, parapet walls, etc., $30; ashlar masonry, $15; rubble masonry, $9; overhaul on stone, $1 per cubic meter per kilometer in excess of 1 kil.

The prices of labor, also in Mexican money, were approximately as follows: Laborers, $1.00 per day; foremen of laborers, $1.50 to $2.00 and board; general foremen, $3.00 to $6.00 and board; American blacksmiths, $3.00 to $4.00 and board; commissary clerks, $3.00 and board; masons and stonecutters, $2.00 to $4.00 and board. A wagon and six mules was worth $6.00 a day, and each additional mule $1.00. Lime delivered on the work cost $1.00 to $1.25 per 100 lb., and Portland cement at the railhead $11.00 per barrel.

There is (or was at that time) a very heavy duty on dump carts, scrapers, harness and tents coming into Mexico. The concession for the railroad admitted free of duty all materials used *in* the construction of the railroad, but not *for* the construction. Standard food supplies cost about as follows in Chihuahua, and it is necessary to add about 40 cents per ton per kilometer for transportation beyond railhead: Beef, native delivered, 25 cents per kilo.; corn, maize, $3.25 per hectolitre; hay, $40 per ton; flour, $6 per 100 lb.; Mexican coffee, 50 cents per kilo.; sugar, 25 cents per kilo.; beans, 7 cents per kilo.; kerosene, 80 cents per gallon.

The climatic conditions of Northern Mexico are nearly ideal for any kind of outdoor work, and railroad construction can be carried on uninterruptedly throughout the year, the only drawback being a lack of good drinking water in some parts. In summer the days are never excessively warm, owing to the high altitude, and in winter, although the nights are quite cold, there is never any frost in the ground.

Location surveys were started in December, 1897, and construction the following spring, the work being practically completed ready for traffic by the spring of 1900. The whole was under the direction of Mr. Ed. S. Safford, M. Am. Soc. C. E., as chief engineer, the writer having had charge of part of the location and construction under his immediate supervision.

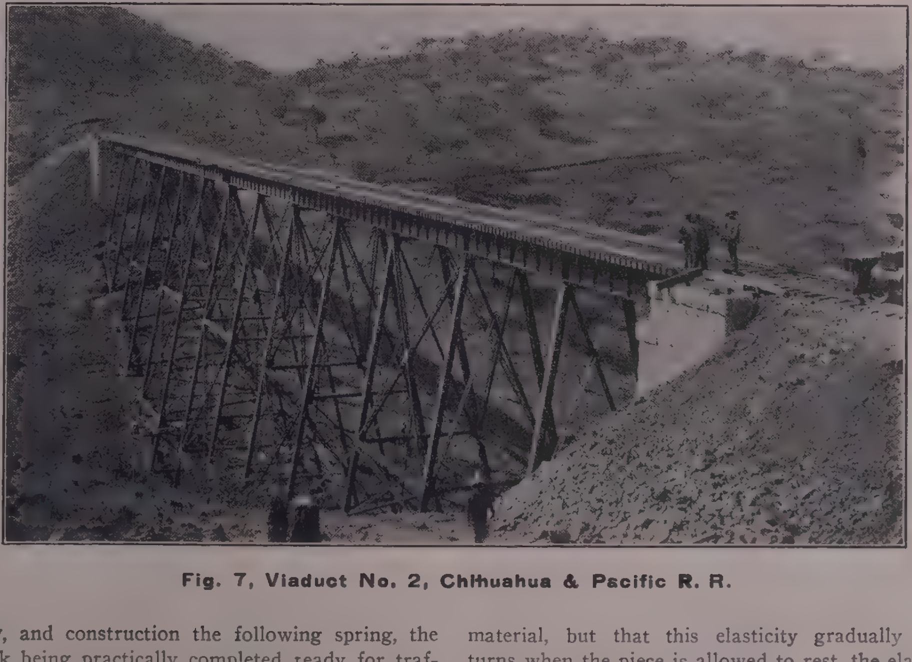


Fig. 7, Viaduct No. 2, Chihuahua & Pacific R. R.

Co-operative Topographic Surveys are now being made by the United States Geological Survey acting with officers or commissions of fourteen states. These states are Illinois, California, Kentucky, Maine, Maryland, Michigan, New York, North Carolina, Oklahoma, Ohio, Oregon, Pennsylvania, West Virginia, New Hampshire.

The California Pump Pit, Cincinnati Water Works.

The great pump pit of the California pumping station of the new Cincinnati water-works has caused some apprehension lest the upward pressure on its bottom should become large enough to rupture it or throw it so far out of alignment as to prevent the safe operation of the pumps resting on it. This bottom is in water-bearing material, into which it was sunk by a pneumatic caisson, as described in this journal some years ago. The recent high water in the Ohio River tested its stability very thoroughly and failed to show any weakness. Although the deck does not yet carry the full load of machinery which it will support when all the pumps are completed, it was exposed to an upward pressure of over 60 ft. without any interference with the operation of the pumping engine now in service. The total maximum upward movement is reported by Mr. George H. Benzenberg to have been less than 0.04 in. It is his opinion, however, that it will be wise as a precaution on the side of safety to admit water to the pump pit whenever the ground-water level rises much over 60 ft. above the deck, so that the upward thrust will be kept at about the equivalent of that head.

Recovery from Overstrain of Nickel Steel.

The recovery from overstrain of nickel and carbon steel has been investigated in the laboratory of Purdue University by Professor E. L. Hancock, who contributed a paper giving the results of this investigation to the recent convention of the Indiana Engineering Society. The tests were made with ordinary structural steel, some of which, however, was given an addition of 3½ per cent of nickel. The investigation showed that an overstrain in either tension or torsion destroys the elasticity of the material, but that this elasticity gradually returns when the piece is allowed to rest, the elastic limit becoming in some cases greater than its original value and the modulus of elasticity the same as its original value. The elastic properties of the overstrained material are restored by immersion for a short time in boiling water. Recovery is not aided by repeated impact from a light hammer. Materials overstrained in either tension or compression lose their elasticity for stress of the opposite kind, but the elasticity is restored by rest. The carbon steel seems to recover more quickly than the nickel steel. This has not been proved conclusively by these tests, but all evidence goes to show that it is true.

THE MINIDOKA IRRIGATION PROJECT, U. S. RECLAMATION SERVICE.

By C. J. Blanchard, Statistician, U. S. Reclamation Service.

The Minidoka irrigation project is located in Lincoln and Cassia Counties, Idaho, and embraces an era of about 150,000 acres of sage brush land on both sides of Snake River. The average elevation is about 4,200 ft. above sea level. The irrigable land is a vast unbroken plain possessing soil of great fertility, a deep sandy loam free from alkali, now covered with a heavy growth of sage brush. The country is lacking in salient topographic features. Knobs and ridges occur here and there, and near the river there is a belt of low sand dunes, which nowhere rise higher than 10 ft. above the level of the surrounding country. The land slopes generally southwestward, rather than toward the river.

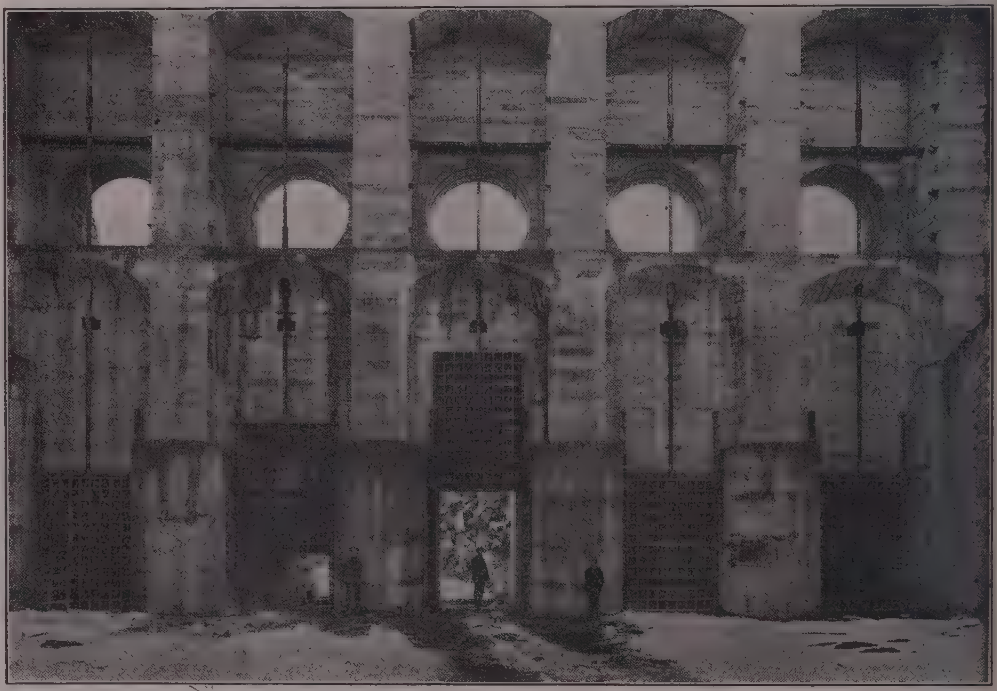
A large area of land in this section was withdrawn from public entry by the order of the Secretary of the Interior, Nov. 17, 1902; and in March, 1903, a party was organized by the United States Geological Survey for the purpose of investigating the possibilities of its reclamation. This party was under the direct charge of Mr. J. S. Burke, Assistant Engineer. A series of trial lines were run on both sides of the river as a basis for making a study of the land and ascertaining the feasibility and probable dimensions of the undertaking. A careful topographic survey followed on a scale of 100 ft. to the inch, with contour intervals of 2 ft., and borings with a 6-ft. coal augur were made, the location of test holes being platted on plane table sheets. A plane table survey was then made for furnishing an estimate of the cost of constructing the necessary distributing canals and for classifying the land. The general direction of this work was in charge of D. G. Martin, engineer, assisted by J. S. Savage, assistant engineer, who prepared plans and drawings. Supervising Engineer D. W. Ross, in general charge of the Idaho work, presented the plans and preliminary estimates to a board of engineers composed of A. P. Davis, assistant chief engineer; Geo. Y. Wisner, and H. N. Savage, consulting engineers, who met at Boise, March 21, 1904, and reported favorably on the project, recommending that $2,600,000 be set aside for the construction of the necessary works. These works consisted of a dam, spillway, forebay canal, and head gates, and a distributary canal system. Bids were invited, and on Aug. 22 a contract was entered into with the second lowest bidder, The Bates & Rogers Construction Co., of Chicago, in the sum of $425,923.00.

The plane table survey on the south side of the river disclosed a large body of very fine land of approximately 80,000 acres above the line of the gravity system, which could only be reached by pumping from 30 to 80 ft. above the level of the river. The designs for the dam were prepared with a view of ultimately supplying this area by pumping, the power to be developed at the dam, and the water to be lifted from the main canal.

The Minidoka Dam.—The location of this dam is about 8 miles southwest of Minidoka, at a point where the channel of the river has been crossed by recurring lava flows of the earlier geological ages. A ridge of lava probably extended at one time entirely across the river channel at this point and the stream has gradually cut its way through it, producing a comparatively narrow opening and a series of rapids. Above the dam site the valley widens out somewhat, forming a small storage reservoir; below it the valley consists of broad and extensive flats suitable for irrigation.

The purposes of the dam are mainly control, diversion and power development. To provide for these purposes and to care for the immense floods to which the river is at times subjected, the dam and appurtenances consist of the following parts: the headworks of the north side canal; the connecting concrete wall extending from this structure to the sluiceway; the sluiceway including the controlling works and power canal penstocks; the main earth and rock-fill dam; the spillway; the headworks of the southside canal; and an earth embankment carried to high ground on the left of the river.

The headworks of the north side canal, and the controlling works, including the connecting wall located on the right bank of the river, form a continuous concrete structure about 350 ft. long and contain about 8,200 cu. yd. of concrete and about 55,000 lb. of reinforcing steel. The headworks of the canal contain nine gates, each 5 ft. wide by 7 ft. high, and the controlling works contain five Coffin gates, each 8 ft. by 12 ft. high. The controlling works are founded throughout on solid rock, and it was supposed before construction that the canal headworks would be similarly founded. It developed, however, in the prosecution of the work that there was a sand and clay deposit in the supposed rock foundation. This caused considerable extension of cut-off walls and foundation excavations.



Diversion Channel Dam, Upstream Face, Showing 8 by 12 Ft. Gates.

The main dam is of the gravity type and is composed of rock-fill, earth and gravel with a concrete masonry core. The height of the dam above bed-rock is about 80 ft. and above the original bed of the stream about 60 ft., and its length about 625 ft. The concrete core wall is built upon a solid rock foundation throughout the entire length of the dam, and at each end reaches to within about 11 ft. of the top of the earth and rock part of the dam, while through the central portion its top is 44 ft. below the crest of the dam. On top the dam is 25 ft. wide, and the bottom width averages about 300 ft. The downstream part of the dam is built of loose rocks of large size, the minimum weight being 1,000 lb., the central part of gravel and small rocks increasing in size towards the large rocks on the lower side, and the upstream part of earth and gravel with riprap covering on the upper portion. The volume of this portion of the structure is 191,000 cu. yd.

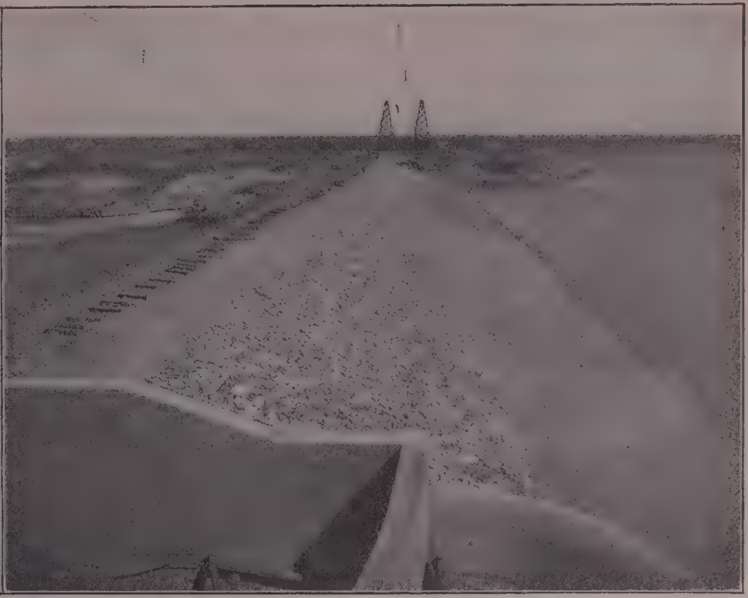
At the south end of the earth and rock dam is a concrete spillway built upon solid rock for nearly half a mile in length. This spillway follows along a broken undulating ridge of lava that has been previously mentioned as extending across the river at the dam site. The spillway is, therefore, very sinuous in its course, following as it does the highest portion of this ridge, and is of varying height, the maximum being 14 ft. In two or three short spaces it is discontinuous, as the surface of the ridge rises above the maximum elevation of the water in the reservoir. The elevation of the crest of this spillway is 10 ft. below the top of the dam, 48 ft. above the bottom of the sluiceway; 7 ft. above the gate sills of the north side canal; 6 ft. above sills of the gates of the south side canal. This structure contains over 4,000 cu. yd. of concrete.

At the south end of the concrete spillway or weir are located the headworks of the south side canal, built of reinforced concrete and having twelve cast-iron gates, each 5 ft. wide by 6 ft. There was used in this structure about 250 cu. yd. of concrete. From this point an earth embankment about 800 ft. in length and averaging 10 ft. in height completes the necessary enclosure of the reservoir above the dam.

In the construction of the main dam, the diversion channel was first built. Two separate masses of fill, the upper one of earth and the lower one of rock, about 150 ft. apart, were then extended across the river from shore to shore, and as the natural channel was thus gradually closed the water was backed up and compelled to flow through the diversion channel. The line of rock-fill was deposited from a cableway and the line of earth-fill was deposited by means of dump cars and trestle work. Between the two masses of fill thus extended across the river the concrete core wall was then built up from the solid rock foundation. Upon its completion the fill was carried up on both sides and over the top of the core wall until the required dimensions of the dam were obtained.

Two cableways about 75 ft. apart, which were stretched across the river parallel to the axis of the dam and located so as to deposit material easily on the site of the dam, greatly facilitated the work. These cables were anchored to large towers on either bank of the stream, and were operated by means of a power plant located on the right bank of the river. The lower cable was used to deposit the heavy rock-fill on the downstream portion of the dam throughout the entire

Top of Spillway, Looking Towards River.



South Side of the Minidoka Dam.

construction. The upper cable was used to handle the concrete material for the core wall and to lay the paving on the upstream slope of the dam. The core wall having been built, the main central body of the dam was built by means of dinky engines and dump cars. The earth and gravel for this portion of the dam were obtained on the left bank of the river below the dam site. The material was loaded on the dump cars at the pit by means of a steam shovel, and was transported in the cars over a movable line of track shifted to cover the dam site.

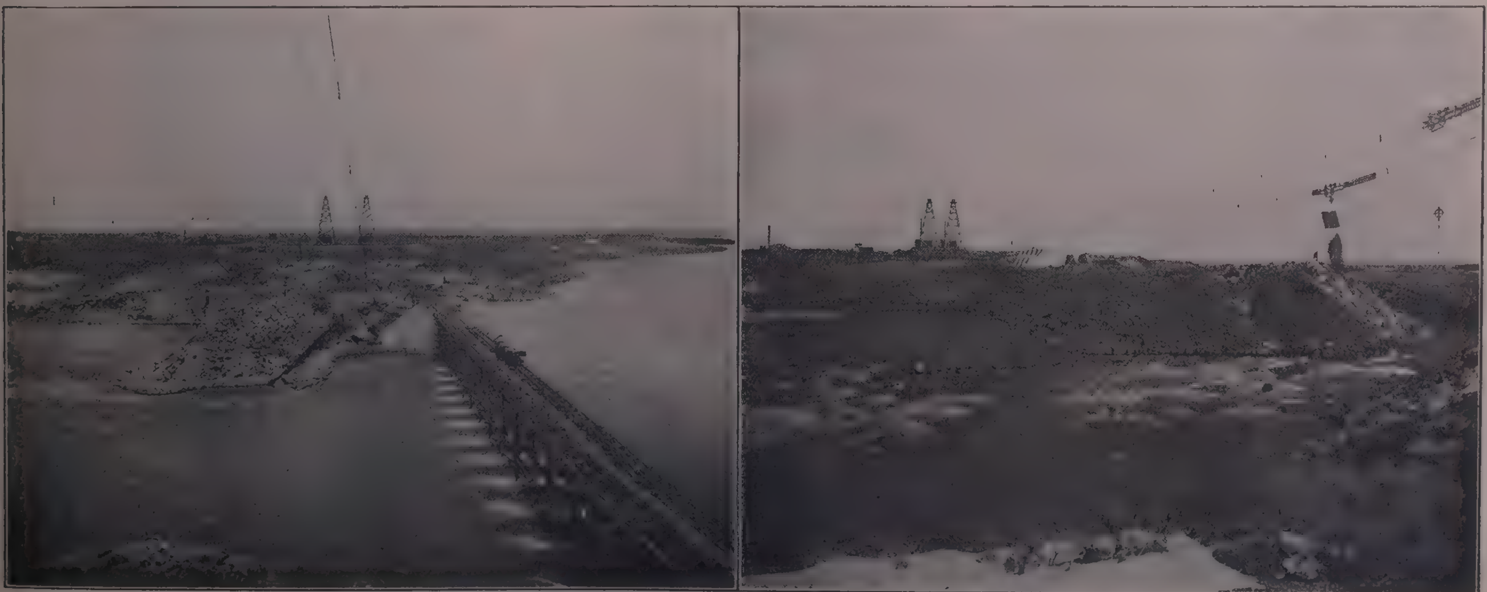
Material for paving the upstream slope of the dam was obtained from excavations for the headworks of the north side canal, which were located almost under the cables adjacent to the cable towers.

The channel of Snake River was closed by the rock fill in April, 1906, and the entire flow was discharged through the regulating gates. The flood flow of this stream was somewhat above normal, the maximum discharge at this point amounting to 24,292 second-feet, occuring June 20, 1906. The unusual cold weather that prevailed all during March and at intervals throughout April, May and June, tended to check the spring and summer floods, which was greatly to the advantage of the contractors. It was fully expected that the river would discharge over the spillway during its high-water stage, but it rose only to within 3.2 ft. of the crest of the weir. Before this stage was reached the rock-fill was raised to its maximum height, which is 13.2 ft. above the highest level reached by the river. At this level the water passed freely through the rock-fill, the leakage being estimated at about 1,000 second-feet, which was evenly discharged throughout the length of the dam. A track was laid on top of the rock-fill, and the gravel and earth for backfilling side dumped from cars into the water. At first a comparatively large percentage of this material was carried into the rock-fill, but the interstices were soon filled and the water completely shut off. The entire loose rock-fill was made water tight under these conditions. The water in the river began falling before the end of June, and there was no further delay in the work from high water.

The structure was completed on Sept. 14, 1906. During the entire progress of the work its general supervision was under Construction Engineer F. C. Horn, assisted by R. M. Connor, assistant engineer.

The natural conditions are unusually favorable for the development of power. A very good site for a power house exists on the north side of the river immediately below the dam. The foundation will be blasted out of solid rock and the water will be delivered to the wheels by means of steel conduits and a supply canal about 150 ft. in length. Up to July 15 the natural flow of the stream will be about 5,400 cu. ft. per second. With storage at the headwaters this flow can be maintained throughout the year and all of it utilized for power. It is believed that the power which can be developed from all sources under this system will range from 11,000 to 30,000 h.-p.

Main Canals and Distributing System.—On Feb. 15, 1905, a project board recommended that contracts be let for the immediate construction of the north side canal and lateral system. In view of the determination not to install a pumping system for the irrigation of lands on the south side for several years, it was decided to construct a small canal to provide for about 8,000 acres on that side by gravity. In letting these contracts the work was divided into eight parts. Schedule 1 consisted of the north side main canal, which contained practically all the rock work on the north side of the river; schedule 2 covered the canal on the south side; schedules 3, 4 and 5 covered divisions of the branch canals and its tributary on the north side; schedule 6 covered the waste canal on the north side; schedule 7 the headgates, turnouts and bridges and other structures; while schedule 8 covered the gates and lifting devices. The contracts were awarded as follows: No. 1, Orman & Crook, Pueblo, Colo., $188,788.30; No. 2, Hubbard & Carlson, Boise, Idaho, $121,494; No. 3, Monarch & Porter, Des Moines,



Views Taken During the Construction of the Dam of the Minidoka Project.

Iowa, $137,184; No. 4, Monarch & Porter, Des Moines, Iowa, $57,642.75; No. 5, Orman & Crook, Pueblo, Colo, $21,576; No. 6, Orman & Crook, Pueblo, Colo., $114,020; No. 7, Orman & Crook, Pueblo, Colo., $30,438.22; No. 8, Vulcan Iron Works, Chicago, $9,471.18.

Work on all of these contracts was begun early in July, 1905, and has been vigorously prosecuted since that time.

The main south side canal has a total length of 13 miles and a capacity of 100 second-feet. It is designed with a view to enlarging it at some future time to a capacity of 800 second-feet. It is 20 ft. wide on the bottom, with side slopes of 2 to 1. In fills which occur at a few places it is 46 ft. wide on the bottom, the banks being of the full dimensions required by the enlarged canal. In shallow cuttings a berm is left on the inside so as to admit of enlarging it to a full bottom width of 46 ft. at a minimum expense. This canal will have a capacity of 1 second-foot for each 80 acres of land, and will irrigate about 8,000 acres by gravity.

The main north side canal is 30 ft. wide on the bottom, has side slopes varying from ½ to 1 to 1 to 1, and will carry water to a depth of 10 ft. for the first 9,000 feet. It is mostly in solid rock. Near the end of the rock cut the canal will drop 12 ft., from which point for a distance of 5 miles it will be mostly in earth, with a bottom width of 46 ft. inside slopes 3 to 1, outside slopes 2 to 1, to carry 7.5 feet of water. The banks will be 10 ft. high and 8 ft. wide on top.

Immediately above the crossing of the railway the canal will be divided into two branches, the "A" branch leading to the south, the "B" branch taking a southwesterly course for a distance of about 15 miles. This branch is carried underneath the railroad in an inverted siphon, consisting of five concrete arched openings, with a regulating gate at the upper end of each opening. The capacity of the main canal near the upper end is 1,200 second-feet. The "A" branch will have a capacity of 423, and the "B" branch 639 second-feet.

These branch canals are each subdivided into several smaller branches with capacities varying from 60 to 200 second-feet. The land on the north side being exceedingly level it was very difficult to get sufficient grade for the lateral system, nearly all the branches and laterals being located on a grade of 1 in 5,000.

All of the principal structures in the main canal and branches consist of concrete masonry. The inside slopes of all canals in earth on the north side are 3 to 1, the outside slopes being 2 to 1, the width of the banks on all the principal canals being not less than 8 ft. and smaller laterals 6 ft. All the banks will be carried 2 ft. above the water surface in the canal. In constructing these canals no runways are allowed on the inside slopes, the material excavated between the banks being hauled up the slope, the tramping of the teams being evenly distributed over all parts of the bank.

The personnel of the Minidoka force was as follows: D. W. Ross, supervising engineer; F. C. Horn, constructing engineer, dam and spillway, D. G. Martin, constructing engineer, main north and south side canals; Edward Hedden, constructing engineer, main branches and distributing system, Minidoka project; J. L. Savage, office engineer; C. B. Smith and J. T. Burke, engineers; G. H. Hogue, J. B. Bond, L. L. Gay, H. M. Hedges, A. M. Gilbert, R. M. Conner, H. S. Williams, C. C. Fischer, R. J. Newell, C. M. King, and W. G. Davies, assistant engineers; Alfred B. Mayhew, Herbert W. Yeo, and Henry L. Lyman, engineering aids; D. H. Blakelock, cartographic draftsman.

Plans for Storage.—As the minimum flow of the Snake River is appropriated for other canal systems, an elaborate storage system has been designed to furnish the supply required for the Minidoka project. For a number of years the Reclamation Service has been making surveys of the several lakes on the head waters of Snake River, with a view of utilizing them for storage purposes. The first of these to be utilized is Jackson's Lake on the south fork of Snake River in Wyoming. Work has been begun on a temporary dam in the outlet of the lake to raise the surface of the water 10 or 15 ft. This dam will be constructed of log cribs filled with gravel. The reservoir thus formed will have a capacity of from 250,000 to 350,000 acre feet. At some later time a permanent structure having a height of 40 ft. will be constructed at this point to raise the lake's surface 30 ft., providing a reservoir having a capacity of from 800,000 to 1,000,000 acre feet. This work is being done by force account since its character, the shortness of the season and the remoteness of the site from railroad points did not tend to make it inviting to contractors. Mr. G. B. Smith, engineer, is in charge of the work.

Partially Completed Cofferdam.

A Remarkable Transformation.—In May, 1904, the Minidoka tract was practically uninhabited. The writer drove across this desert and camped for the night on the banks of Snake River, at a point which was then selected as the site for the future metropolis of the valley. With the supervising engineer he drew a rough plan of the town, which was subsequently approved by the department. That night, save for their campfires, there was no other evidence of human habitation within 30 miles of us, only a vast expanse of sage brush, extending to the horizon. To-day you reach this point on a railroad, and pass through three towns to get there. These towns contain more than 150 business establishments, including three newspapers and three banks. They are well supplied with schools and churches. Every 80 acres of that desert now has a family living upon it, and where only a little over two years ago the desert held full sway nearly 4,000 people are settled to-day. The sales of lots in those new towns netted Uncle Sam more than $100,000 and all are not sold yet.

The Preparation and Use of Maps is described in the "Manual of Topographic Methods" by Mr. Henry Gannett, which has been published by the U. S. Geological Survey for free distribution.

Steel Sheet Piling for Bridge Pier Cofferdams.

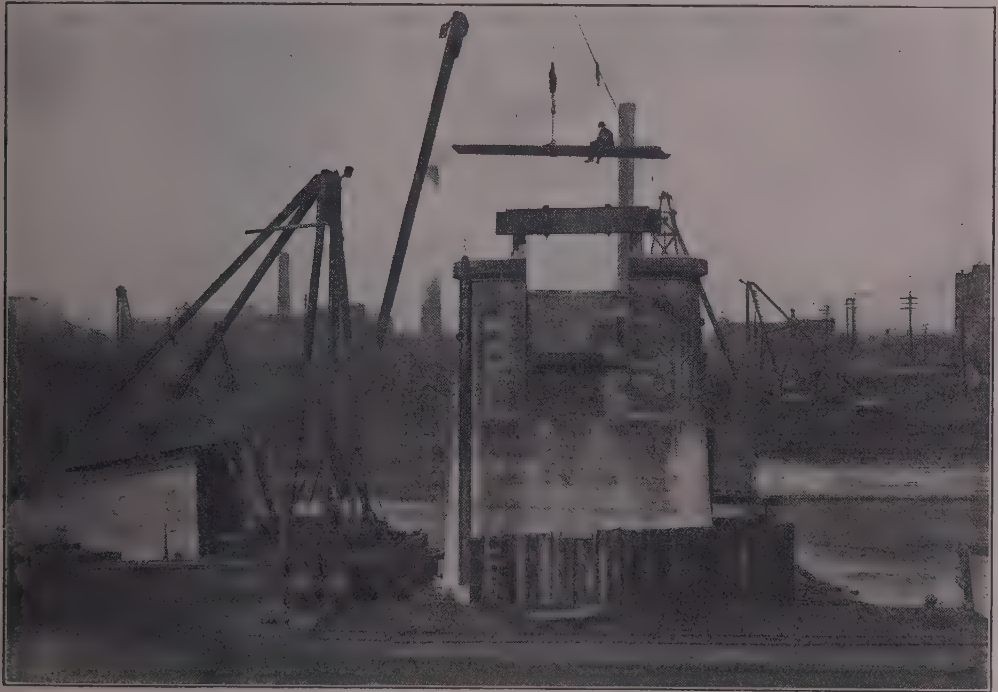
The new electric railway of the Illinois Traction system extending from Bloomington to Peoria, Ill., enters the latter city on a steel bridge over the Illinois River, which has five spans over the water and seven spans on land, all carried by concrete piers. The river spans are all about 140 ft. long and are 38 ft. above low water level, which level is about 12 to 14 ft. above the bottom in the channel. Since the opening of the Chicago Drainage Canal, however, the river has never reached the low-water stage and during the construction of the bridge piers was not below 7 ft. above low water and rose to 12 ft. above that stage. The stream has a width of nearly 700 ft. at the crossing, its bottom consisting of hardpan on the Peoria side, which grades off into black soil covered by sand on the opposite side. Bed rock is found approximately 20 ft. below the bottom of the river and on this rock the piers for the river spans were built in cofferdams.

Arrangement of Mixer Plant.

The channel span of the bridge is a Strobel rolling lift bascule draw and the other four stream spans are all of the Pratt truss type. The draw span requires two separate piers and as the ends of the Pratt truss spans adjoining it each require pier supports, two piers are built on the same footing at each end of the draw span. These four piers and one of the other river piers were built in cofferdams made of the steel sheet piling manufactured by the Friestedt Interlocking Channel Bar Co., of Chicago. The remaining river piers were in shallower water and were built in ordinary cofferdams made of three rows of 3x12-in. Wakefield sheet piling back-filled on the outside with material from the excavation.

A 900-ft. span Lambert cableway with a carrying capacity of eight tons was set up over the longitudinal center line of the bridge site and was used in handling all the materials for the cofferdams and the forms and concrete for the piers. The river bottom at the site of the piers was first dredged out down to a 2½ to 3-ft. layer of slate and soapstone that overlies the rock, except at the site of one pier where 16 ft. of hardpan was also encountered. This work was done with a 1-yd. extra heavy orange peel Hayward bucket handled from the end of a 60-ft. boom of a derrick mounted on a derrick boat. When the excavation had been made large enough so the slopes of the material over the slate and soapstone would stand and leave the latter exposed over the site of a pier, the construction of a cofferdam would be started.

The pairs of piers at each end of the draw span are on a single footing, 34x38 ft. in plan. The cofferdams for these two pairs of piers were accordingly each made 39x43 ft. in plan. The steel piling forming the sides and ends of the cofferdam was braced across the latter with five longitudinal and six transverse rows of 12x12-in. timbers to hold it in place when the water had been drawn down in the cofferdam. These timbers were placed in nine horizontal layers, varying from 2½ to 5 ft. apart from the bottom to the top of the cofferdam. The horizontal layers were held apart by a vertical 12x12-in. timber at each intersection of the rows of braces. The timber crib formed by these braces and verticals was built in the water approximately over the site. The horizontal layer which would come at the level of the top of the slate and soapstone in the cofferdam was first assembled as a raft on which the verticals were erected and then the second horizontal layer was placed, sinking the crib thus formed to the water level. The various horizontal layers were thus added in succession and when they had been completed the crib was towed over the site, sunk in position and anchored.



Pulling Sheet Piling of One of the Channel Cofferdams.

The steel sheet piling was then brought out from the shore, four to six pieces at a time by the cableway. The driving was done with a 3,000-lb. drop hammer operating in leads suspended from the end of the boom on the derrick boat. A cushion head consisting of two heavy flat steel castings, placed one over the other in the leads and spaced apart with heavy oak timbers that were kept wet to serve as a cushion, was placed on each section of the piling during the driving to avoid battering the heads of the sections. The two castings were bolted together and the upper one carried a heavy oak cap on which the blows of the hammer were received. The piles were driven mostly through the dense slate and soapstone overlying the rock and penetrated 2½ to 3 ft. of these materials before reaching the latter; at the one pier the 16 ft. of hardpan was also penetrated by the piling before reaching the slate. The piles penetrated the slate, soapstone and hardpan without difficulty, although frequently the penetration was not more than ½ in. per blow, without being battered in any way and were afterward drawn and redriven.

The piling forming the sides and ends of a cofferdam was driven in this manner in from 3 to 5 days. After a cofferdam was completed the excavation was back-filled on the outside of the piling up to the level of the river bed in order to firmly anchor the lower ends of the piling, the latter being depended upon entirely to produce a water-tight cofferdam. The water in the cofferdam was pumped out with an 8-in. Morris centrifugal pump mounted on the bracing and supplied with steam by a boiler set up on a scow anchored beside the cofferdam. This pump could remove the water in one of the large cofferdams in 1¼ hr. After the bottom had been laid bare the water was kept down to the top of a sump in the strata of soapstone by a 6-in. Morris centrifugal pump which had to be operated only about half the time, as very little seepage occurred through the piling and practically all of the water that entered the cofferdam came through along the surface of the rock under the bottom of the piling. Some slight leakage took place through the joints between the sections of piling, but this was always readily stopped by throwing a few fine bituminous coal cinders from the furnace of the boiler on the derrick boat into the water on the outside of the cofferdam close to the leak.

The slate and soapstone overlying the rock were removed with picks and wedges and taken out in 2-yd. buckets by the cableway after the water had been drawn down. When the crib of bracing holding the sides and ends of the cofferdam apart was lowered it rested on this slate and soapstone, so when these materials were removed it had to be blocked up in place and additional horizontal layers of bracing put in as the excavation went down. This blocking and additional timbering was done without difficulty and the rock easily laid bare.

The concrete for the piers in the river was made in a mixer plant set up on the river bank immediately adjoining the head tower of the cableway. The concrete was made of 1 part Atlas Portland cement, 3 parts bank sand and 5 parts broken limestone. A 1½-yd. cube mixer was set on a platform 8 ft. above the ground and over it were erected a supply bin for sand and one for stone, the one for the former having a capacity of 30 cu. yd. and the one for the latter of 60 cu. yd. The sand and stone were delivered from railroad cars into storage piles near the plant. Two bucket elevators were provided for raising these materials to the supply bins over the mixer. The lower ends of these elevators were in hoppers under a service track on which small dump cars delivered the materials from the storage piles; the sand and stone could also be shoveled into these hoppers by hand. The cement was stored in a shed nearby and was delivered on the service track to the foot of an elevator at the plant which raised the bags to the charging platform around the mixer. The latter discharged directly into 2-yd. bottom dump buckets on flat cars on a track under the platform on which it was erected. This track extended out under the cableway and the latter handled the buckets to place in the cofferdams.

The bracing in the cofferdams was 8 ft. apart on centers in both directions so the buckets could be lowered into the pockets formed by it. The cableway being set over the transverse center line of the cofferdams, the buckets were most conveniently lowered into the pockets on that line. By setting a portable inclined platform on the bracing under the point where the bucket would discharge, the concrete could be readily delivered to the ends of the piers, as well as directly under the cableway. As the footing for the piers was completed the blocking and lower layers of bracing were removed. The forms for the piers were then built up in section as the concrete was carried up, the original bracing being removed and the sides of the cofferdam braced against the pier until the completion of the latter.

Only enough of the steel sheet piling for the two large cofferdams was secured, but after the piers in one of the cofferdams had been finished the piling was pulled and redriven for the third cofferdam. The steel piling was all pulled without difficulty by the derrick on the derrick boat as the work was completed and was without exception in good enough condition to be used again a number of times after the whole job was finished.

The wooden cofferdams for the remaining piers in the river were built without much trouble. The material over the slate and soapstone was excavated at the piers by the derrick boat, the same as at those where steel sheet piling was used. The cofferdams were then built and forty-four oak piles, 10 in. in diameter at the point, were driven to the rock in the excavation to carry the footing for each pier. These piles penetrated about 12 ft. of material and were cut off in the cofferdams 3 to 4 ft. below the elevation of low-water in the river.

All of the work on the sub-structure as described was executed by Mr. Frank J. Cullen, of Chicago, as a sub-contractor under MacArthur Bros. & Co., which company was awarded the general contract for the entire bridge. The bridge was designed by Mr. Ralph Modjeski, of Chicago.

THE FULL VALUE OF ALCOHOL is roughly indicated by road tests recently made by three Maxwell automobiles in a run from New York to Boston, a distance of 249 miles. The cars were identical except that one used gasoline, one kerosene and one denatured alcohol. The average run was 10.1 miles per gallon of gasoline, 8.13 miles with alcohol and 7.4 miles with kerosene. This is equivalent to a fuel cost of 1.39 cents per ton-mile with kerosene, 1.69 cents with gasoline and 4.48 cents with denatured alcohol. The cost of the latter seemed to be its only drawback during this test. According to those who made the trip, the engine operating on alcohol pulled more strongly on hills than those operating on either kerosene or gasoline. Although the trip was made over roads in bad shape for motoring, the actual running time averaged almost 15½ miles an hour.

Building the Washington Street Bridge in Dayton, Ohio.

Washington St., Dayton, Ohio, formerly crossed the Great Miami River about 20 ft. above low water on a steel bridge having three Pratt truss spans. This structure had a 20-ft. roadway, with a 5-ft. walk on each side, and carried two street railway tracks. The Great Miami River is about 600 ft. wide at the crossing during ordinary low water and has 2 to 5 ft. of depth. The stream is subject to frequent and sudden rises in the spring and early summer, a depth of 15 to 16 ft. generally being reached once or twice during each year.

The capacity of the old bridge having become too limited for the traffic it was required to carry, the decision was made to replace it with a reinforced concrete structure. Accordingly, the Concrete-Steel Engineering Co., of New York, was retained to prepare detail plans and to supervise the construction of the new bridge. This bridge is very similar to one that was designed by the same company and was built to carry Third St., in Dayton, over the Great Miami River. A full description of the Third St. bridge and the methods used in its construction was printed in The Engineering Record of March 24, 1906. The design of the Washington St. bridge and the manner in which it was built are both different, however, from those of the one at Third St., so a full description of the Washington St. bridge is given herewith.

General View of the Washington Street Bridge at Dayton, Ohio.

The Washington St. bridge is of the Melan arch type, and has seven spans, with a total length of 620 ft. from face to face of abutments and a clear width of 54.75 ft. The bridge is symmetrical about the transverse center line of a 90-ft. span at the center with a rise of 11 ft. 5 in. On each side of this center span are three successive spans of 86 ft., with a rise of 10.5 ft., 80 ft., with a rise of 9 ft. 3 in., and 74 ft., with a rise of 8 ft. 1 in. The springing lines of all the arches are at the same elevation so that a camber of 4.1 ft. is introduced between each end and the center of the bridge. This camber and the difference in the dimensions of the spans produce unbalanced thrusts at the piers, but these differences are not great enough to necessitate any reinforcement at the ends of the spans other than that provided by the built-up lattice steel girder ribs with which the arch rings are reinforced.

The bridge was designed on the assumption that the dead loads are produced by concrete at 150 lb. per cubic foot, spandrel filling at 120 lb. and brick pavement with a 6-in. concrete base at 150 lb. The 36-ft. roadway and the 9-ft. walks on each side of it are built to carry a live load of 150 lb. per sq. ft., the roadway being proportioned for the additional concentrated load produced by a 40-ton street railway car. A maximum unit compressive stress of 500 lb., a tensile stress of 50 lb. and shearing stress of 75 lb. per square inch, all exclusive of temperature stresses, was allowed in the concrete. The built-up girder ribs in the arch rings are designed to take all the bending moments produced in the arch without being stressed more than 18,000 lb. per square inch and have flange areas not less than 0.0066 of the total cross-sectional area of the concrete in the arch ring.

The built-up ribs with which the arches are reinforced have top and bottom flanges, each composed of two 2½x2½x5/16-in. angles, the flanges being latticed together by ¼x1½-in. bars. These ribs are placed uniformly 3 ft. apart on centers and have a depth varying with the thickness at the crown of the arch rings, which thickness varies from 17 in. in the 74-ft. span to 20 in. in the 90-ft. span. Each rib was fabricated in three sections in the shop, and the sections spliced together after they had been placed in position on the centering. The top flanges of the corresponding girders in the various spans are also spliced together over the piers so as to form continuous reinforcement. The lower flanges are anchored into the piers and abutments by 2½x2½x5/16-in. angles extending the full width of the bridge.

The concrete was made in three proportions as follows: For the arches between skewbacks, and for pedestals, railing and parapet walls, 1:2:4; for piers, abutments and wing walls, 1:3:7; and for spandrel walls, 1:3:6. Castalia Portland cement, bank sand and bank gravel were used in all except the arch. The latter was made with 1½-in. crushed stone. All concrete surfaces exposed to view or to the weather were finished with a 1:2½ mortar facing having a minimum thickness of ½ in. This facing was in all cases carried up with the concrete in such manner as to avoid any plane of demarkation and no plastering of surfaces was permitted. After the completion of the arch and spandrel walls and before the spandrel filling was put in, the top surface of the arch and abutments and the inner surface of the spandrel walls were given a heavy coat of pure Portland cement grout. Over this two courses of tar paper were laid in melted coal tar pitch and the entire surface of water-proofing was then covered with coal tar pitch at least ⅛ in. thick.

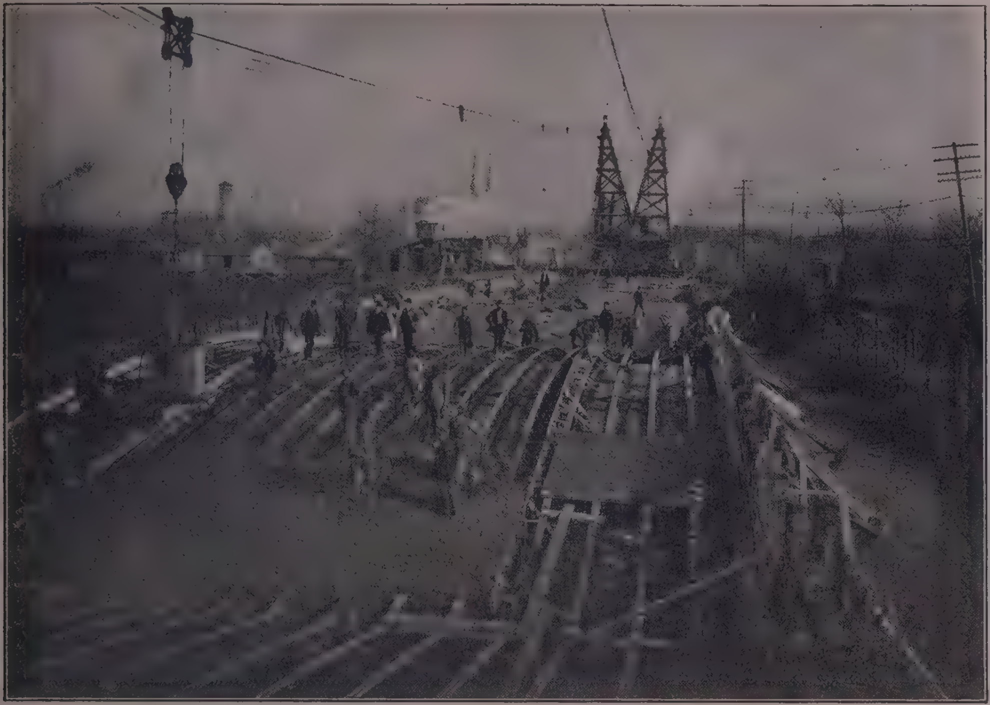
The spandrel filling consists of sand and gravel obtained from the river at the site. Provision for the drainage of this filling is made at each pier as follows: Four 3-in. wrought-iron pipes are built into the concrete and extend from the top of the pier down through the latter to an opening in the side just above low water. The surface of the concrete over the piers is formed so water will drain to the pipes, the line of drainage being covered with a layer of broken stone and the tops of the piers being protected with a screen to prevent clogging.

During the construction of the new bridge a temporary timber structure carried by pile bents was built 80 to 200 ft. downstream from the center line of the street. This temporary bridge had a 20-ft. roadway and carried a street railway track. The pile bents were spaced 16 ft. apart, except at the point opposite the center of the channel spans of the new bridge where two alternate spans were omitted making two free waterways of 30 ft. The piles were driven by a 2,500-lb. drop hammer. The driving outfit was mounted on a platform on rollers and was moved forward on the finished work as the driving progressed.

Two 850-ft. span Lambert cableways were set longitudinally over the site, one 13 ft. on each side of the center line at the inception of construction and handled all the centering, forms and materials used in building the bridge. These cableways had 75-ft. towers and 2-in. cables. The cables cleared the highest point of the concrete work in the bridge by 30 ft. when loaded; the hoisting tackle and load occupied 10 to 15 ft., so that a net clearance of at least 15 ft. was always attained. The cableways had a capacity of 8 tons, but the usual working load did not exceed 5 tons. Signaling to the hoisting engineers operating the cableways was all done by telephone from boxes placed at convenient points on the temporary bridge.

The concrete mixing plant was set up on one side at the end of the bridge next to the head towers of the cableways. These towers were placed far enough back from the abutment at that end to provide space for loading materials, and for two tracks from the concrete mixing plant. The gravel and sand used in the concrete were obtained from a bank about 3 miles from the bridge, and were hauled in on 10-yd. bottom dump cars on a street railway. It was also found necessary to use bottom dump wagons during part of the work to keep up the supply of material. The bottom dump cars and wagons in which the sand and gravel were delivered were driven up an incline erected over receiving bins near the concrete mixing plant and their contents discharged into these bins. Two parallel narrow-gauge tracks extended from under the latter up an incline to a platform over elevated storage bins at the mixing plant. The sand and gravel were discharged from the receiving bins through two-way chutes into 2-yd. cars on these tracks. The cars were hauled up the incline by a hoisting engine and could handle about 100 cu. yd. of material a day.

The concrete was made in two cubical mixers, which were set up under the storage bins so that the sand and gravel could be fed into them by gravity. The cement was stored in a shed near by and was hauled up an incline to the charging platform at the mixer on flat cars. The mixer discharged into 2-yd. bottom dump buckets on flat cars on the narrow-gauge tracks that extended out in front of the head towers of the cableways. The mixing plant had a normal working capacity of 400 cu. yd. per 10-hr. day, although as high as 475 cu. yd. were produced by it in that length of time. In all 13 men were required to operate it and were distributed as follows: 4 men at the receiving bins, 1 hoisting engineer, 2 men on the car unloading platform, 2 men handling cement, 2 men at the mixers and 2 men hooking the buckets to the cableways and in cleaning up on the tracks. Based on the normal capacity of the plant and this number of men the average labor cost for mixing concrete was $0.1367 per cu. yd., the average cost of labor being $2.25 per 10-hr. day.

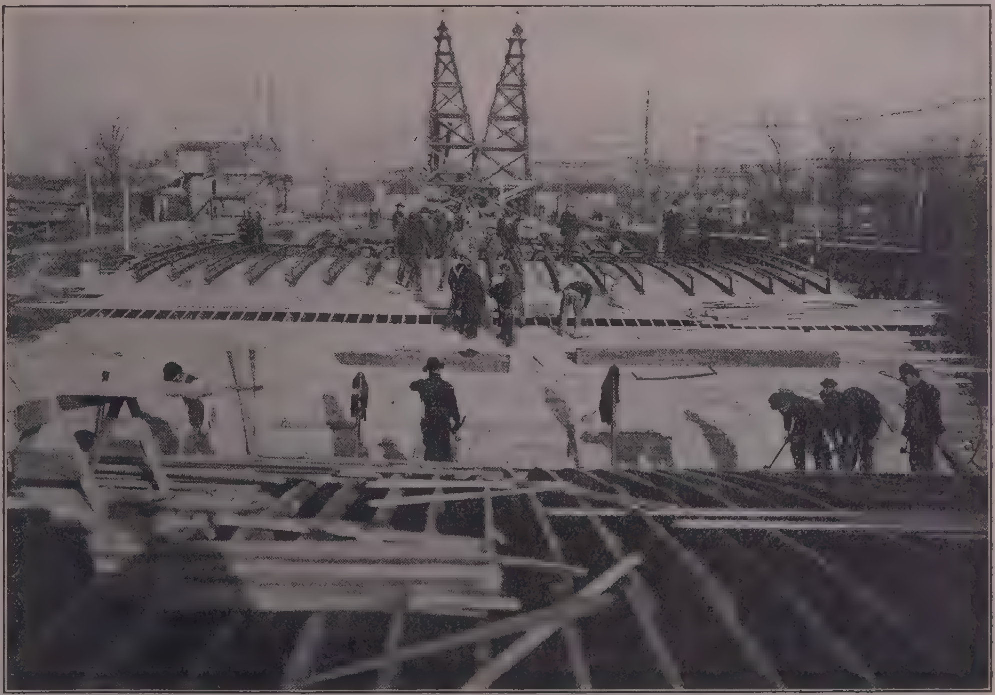

Concrete Work in Progress on an Arch Ring.

The cableways carried the buckets of concrete directly to place from the flat cars on which they were delivered from the mixing plant. The two cableways could readily handle an average of 500 cu. yd. of concrete a day in this manner.

The footings for the two abutments and seven piers of the bridge were all built on a stratum of gravel which underlies the site, no piles being required in the foundation. The footings for the piers extend 12 to 18 ft. below low water so that they and the lower parts of the piers had to be built in pits sheeted with 4x12-in. planks splined together and backed with material from the bed of the river. Some difficulty was experienced in this work, as the river rose 6 to 7 ft. at different times while construction was in progress.

The falsework centering for the arches consisted of transverse pile bents spaced 11 ft. apart, with the piles in a bent 7 ft. apart. These piles were cut off about 3 ft. below the intrados of the arch and were capped with 4x12-in. timbers. On these caps were pairs of wedges supporting a 12x12-in. upper cap on which were placed 57 lines of longitudinal 2x12-in. ribs, 12 in. apart on centers. These ribs were laid as chords of the curve of the arch and on them were nailed pieces cut to that curve. The lagging consisted of 1x6-in. tongue and grooved flooring finished on one side. The center bent was omitted in the falsework for the channel spans so that a clear water way of 30 ft. was thus provided. The blocks carrying the ribs of the arch forms were carried over this span by 12x12-in. timbers supported at the ends by the pile bents. In all of the arches the centering was built with a rise one-eight-hundredth in excess of the span shown on the plans.

The concrete for the footings of the piers was laid in the bottom of the sheeted pits, planks forming the offsets being the only forms used. The piers were built in forms composed of 1x6-in. tongue and grooved plank nailed to vertical waling pieces and the whole braced against the sides of the sheeted pit. These forms were built in sections and after a pier was finished they were taken down in these sections and moved to the side of another pier by the cableway. The footings were built in layers 6 to 8 in. thick which were rammed as the concrete was placed. The tops of the piers were finished so the haunches of the arch rings were normal to them. The abutments were built in layers normal to the thrust of the arch.


Building Arch Forms and Placing Steel Reinforcing Ribs.

The piers were all carried up to the springing lines of the arches before concrete laying was started on any of the latter. The piles of the falsework for the centering for the arches was driven while the work on the piers was in progress. The arch forms were all built and the reinforcing ribs for all the arches placed before any of the concrete work above the tops of the piers had been commenced. The arch at one end was built first and the other arches were built in regular succession from that one to the other end of the bridge. The concrete in the arch rings was placed in one or two longitudinal sections, the sections being separated by forms placed between the girders while concrete work was in progress. The work in a section was started at both haunches of the arch at the same time and was carried up simultaneously to about one-third the distance between the skewbacks and the transverse center line. The concrete was then started to the center and advanced toward the portions that had been carried forward from the skewbacks.

The forms for the spandrel walls were braced against the caps on the falsework carrying the centering of the arches. These walls were built after all of the arch rings had been completed. When the water-proofing on the upper surface of the arch rings and the backs of the spandrel walls had been laid, the spandrel filling was put in place. A traveling stiff-leg derrick equipped with a 1-yd. Hayward orange peel bucket and with its mast and boom operated by a bull wheel, was set up on the bridge, and dredged from the bed of the river the sand and gravel used for spandrel filling. This derrick was moved forward as the filling was completed and placed 3,200 cu. yd. of material between the spandrel walls in twelve days.

The copings and railings on the spandrel walls are made of 1:2:4 concrete, with all exposed faces of 1:2½ mortar, at least ¾ in. thick. The coping and posts over the piers were molded in place. The base, balusters and tops were cast in 5-ft. lengths in wooden forms in a shed near the bridge. The sections were kept moist after 24 hrs., for at least 10 days and were protected from the sun. The coping, balustrade and tops were built of the sections which were keyed together and laid in cement mortar. The coping and railing built in this manner has a uniform appearance and is free from hair cracks.

The falsework and centering for the arches was all left in position until the spandrel filling had been placed, as no high water of any moment was experienced during the construction. The concrete in the arch rings thus had an opportunity to set from 28 to 43 days before the centering was removed.

Work on the new bridge was started in July, 1905, the last pier being completed Nov. 16, following. The erection of the falsework and centering for the arches was carried forward as rapidly as possible during the construction of the piers. Concrete work on the arches was started Dec. 2 and completed Dec. 15; the spandrel walls were completed one week later and the 3,200 yd. of filling was placed in 12 days. The structure then being practically completed, work was abandoned on the sidewalks and paving until spring on account of the weather, which also prevented the street car tracks being built.

Clam Shell Bucket used in Placing Spandrel Filling.

The bridge was built under the direction of Mr. F. M. Turner, city engineer of Dayton, and under the immediate supervision of Mr. Wilbur Pease, resident engineer. The contract for the construction was awarded to Mr. Frank J. Cullen, general contractor, of Chicago, Ill., for $117,000, the total cost of construction being between $121,000 and $122,000.

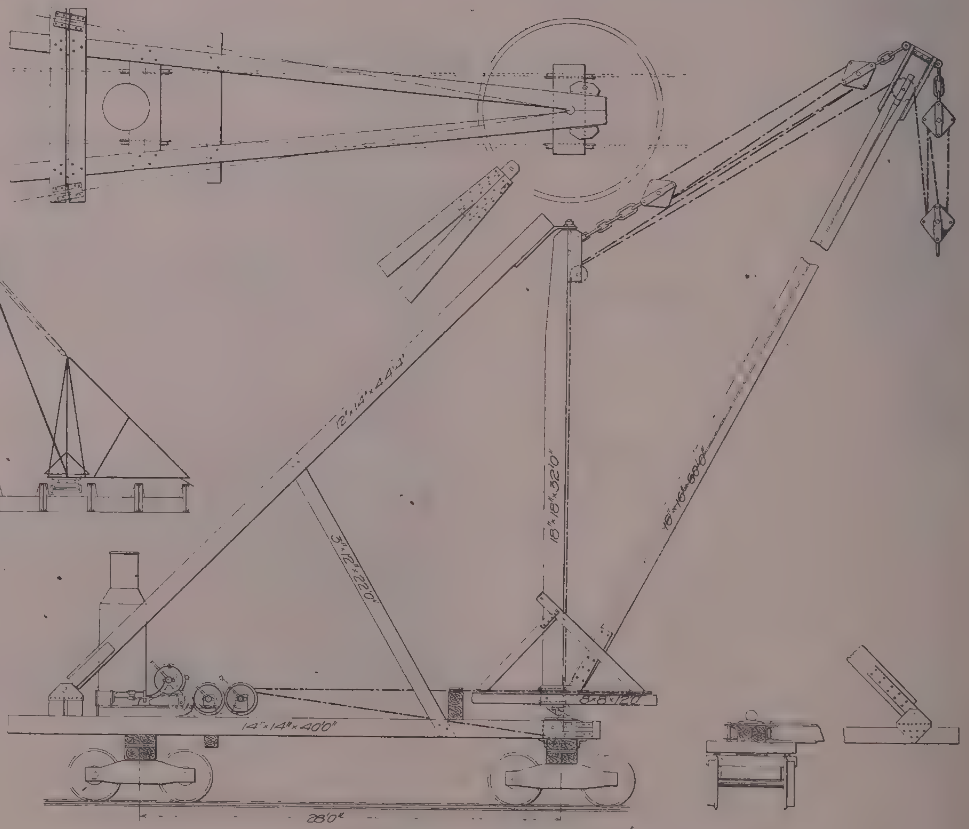
A Great Drainage Project has been recommended by the Secretary of the Interior for the benefit of the 600 square miles of lowlands in the old Red Lake Indian Reservation just northeast of Thief River Falls, Minn. The farmers living upon this area find themselves practically isolated for several months each year, because of the great stretches of swamp which entirely surround their holdings. When reclaimed by drainage, these swamp lands will rank with the best farms of the region. The report sent to Congress contains a recommendation for the construction of a complete system of drainage, which would cost nearly $1,100,000. The suggestion is made that if Congress will appropriate this sum for the work, the money may be returned to the Government in the manner provided under the Reclamation Act of 1902, in ten annual installments by settlers upon the reclaimed land or by present owners of improved lands. The plan of drainage recommended provides for two main ditches, from 4 to 6 miles apart, each about 40 miles long, with laterals at right angles located about 7 miles apart Minor drainage ditches should reach each 160-acre lot. Such works will accomplish the drainage of 266,750 acres of Government and private land and the improvement of 135,750 additional acres, making a total of 402,500 acres that would be benefited. The Government lands are open to settlement under the homestead act upon the payment of $1.25 an acre, the fund thus obtained being devoted to the Chippewa Indians. Pending action by Congress the lands must remain withdrawn from sale.

A Traveling Derrick for Erecting Girder Bridges.

Sixteen spans of four-track through and pony girder bridges, weighing altogether about 3,000 tons, have recently been supplied and erected on the New York, Westchester & Boston Ry. by the Terry & Tench Co., New York. Eight of them were erected with a special stiff-leg boom derrick mounted on swiveling four-wheel standard gauge trucks 28 ft. apart on centers and designed both to operate on the permanent track and to move on it from side to side along the four-mile section on which the spans are located.

The main frame of the derrick had a horizontal platform with two 14x14-in. sills 40 ft. long, diverging from their intersection at the foot of the mast to a width of 9 ft. apart on centers at the rear end, just beyond where they were supported on the truck bolster above which a double-drum Lidgerwood engine was seated to counterbalance the derrick load. An 18x18-in. mast 32 ft. long was centered over the bolster of the forward truck and its upper end was braced by a pair of 12x14-in. stiff legs about 44½ ft. long, which diverged to 11½ ft. apart on centers at the lower end where they were connected to a double horizontal transverse sill across the tops of the longitudinal sills on the trucks. This framework formed a tripod with a long narrow base sufficient for stability when the derrick was out of service. To give it a wide base for handling heavy loads with a long boom, it was provided with a third stiff-leg consisting of a single 12x14-in. timber pivoted to the top of the mast and having its foot attached to a horizontal 14x14-in. sill 40 ft. long, with the inner end hinged to the transverse timbers supporting the foot of the mast.

When in service the sill was revolved at right angles to the track, and the outer end was blocked up from the ground or was blocked and bolted to the top of the outside girder in the span last erected. When the derrick was moved forward, the boom was lowered to rest on a flat car placed in front of it for that purpose, and the pivoted stiff-leg was revolved horizontally until it was nearly parallel to the plane of the boom and the forward end was supported on the same car. The derrick was then advanced on the construction track to the next site, the transverse stiff-leg swung into position, and the derrick made ready for service within a very few minutes, the stiff-leg being handled by a runner line from the hoisting engine.



Traveling Derrick used in Erecting Girder Bridges.

Ordinarily the derrick was operated on one of the middle tracks of the span but could be used on any of them by means of a stationary derrick which lifted the rear end of the longitudinal sills from the truck and revolved it 180 deg. around the front truck, reversing the direction of the derrick so as to throw the stiff-leg from right to left, and seating it again on its truck after the latter had been carried around to the other side of the forward truck.

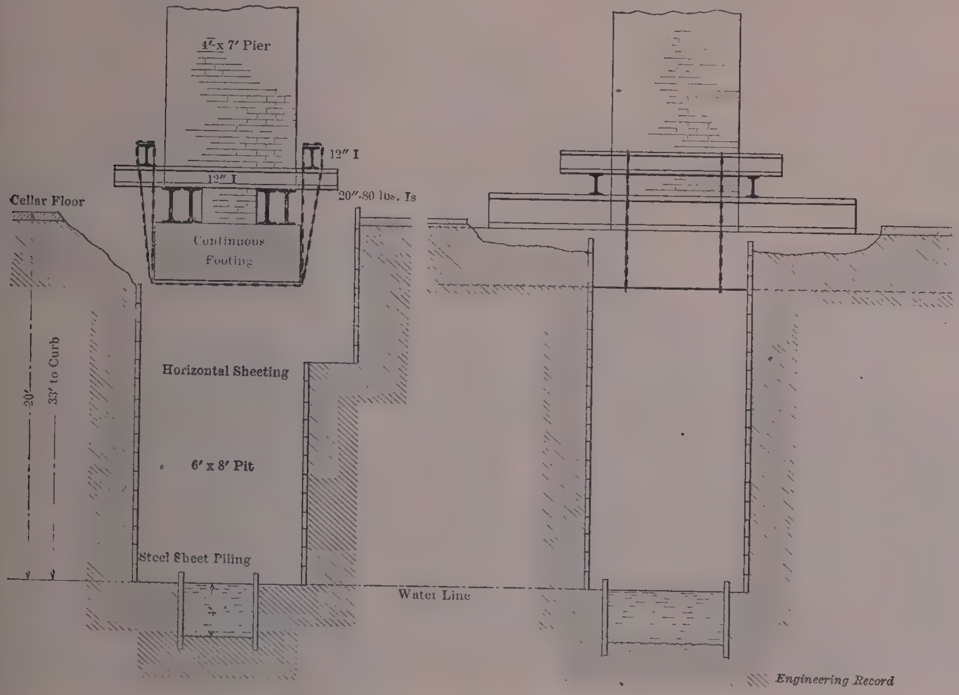
The derrick fittings were entirely of forged and cast steel, no cast iron being used in its construction, and were all of the Terry standard patterns. The feet of the stiff-legs were secured to the sills with pins through riveted shoes and side plates, the former being seated on the tops of the sills and fastened to them with both vertical and horizontal bolts, as indicated in the detail drawing. The goose-neck connecting the longitudinal stiff-legs to the top of the mast was a single steel forging about 5 in. thick, and was bolted to a wider plate engaging both of the stiff-legs and splicing them together. The sheaves at the top of the mast were set in a riveted box containing the gudgeon, and were mounted in such a way as to give great strength without cutting the timber. The foot of the mast was fitted with a Terry standard cast-steel locked ball-and-socket bearing, with a hole through the center for the lead lines from the hoisting and topping lifts to the engine. The boom was made from 16x16-in. timber 60 ft. long, set with its diagonal in the vertical plane, thus giving an estimated strength equivalent to an 18x18-in. timber set square. At the point, it was provided with a special riveted box and links providing connections for the tackles without weakening the timber. A 12-ft. bull wheel was attached to the foot of the mast, and a cable engaging it was operated by a special drum on the hoisting engine to swing the boom. Each truck was fitted with a double bolster and swivel, and when in service pairs of wedges were driven between the ends of the bolsters to give them solid bearing and increase the stability of the derrick. The heaviest pieces handled by the derrick were 22-ton plate girders 80 ft. long, which were delivered on the construction track and erected by it without difficulty.

The bridges were designed under the direction of the engineering dpartment of the railway, Mr. Wm. A. Pratt, chief engineer, and Mr. Paul A. Kirchner, engineer of bridges, and were built by the American Bridge Co. for the Terry & Tench Co.

Underpinning Business Buildings Adjacent to the Brooklyn Subway.

The rapid transit railway subway in Fulton St., Brooklyn, was originally a three-track steel and concrete structure on the center line of the street. Later it was decided to extend it by the addition of two or three more tracks, in some places at the same level and in other places at a lower level. Their construction has encroached on the sidewalk vaults and extends from 10 to 20 ft. below the footings of the wall piers of heavy four and five-story business buildings. It has therefore been necessary to underpin the piers before making the subway excavation and the concrete footings have been carried down 20 ft. farther than their original level by simple and efficient methods which involved only the excavation of pits of the required size of the new footings.

A typical case is shown in the accompanying sketch of the underpinning of one of the 4x7-ft. piers for the five-story Woolworth Building where the original concrete footing was seated on sand about 15 ft. below the curb. Recesses were cut on opposite sides of the pier at the floor level, just above the top of the 6x6-ft. concrete footing 2 ft. thick. In them pairs of 20-in., 80-lb. I-beams 18 ft. long were set and wedged to bearing. The ends of the beams were supported on transverse sills distributing the load over the concrete basement floor. Although the continuous heavy footing probably would develop sufficient beam strength to carry itself safely across the excavation, it was additionally supported by chains attached to 12-in. I-beams parallel with the wall seated on the cantilever ends of 12-in. I-beams across the top flanges of the main girders.



Underpinning the Woolworth Building in Brooklyn.

An 8x8-ft. pit was sheeted down to a depth of about 2 ft. below the bottom of the footing and afforded an entrance to a 6x8-ft. pit excavated directly under the footing concentric with the brick pier. As this excavation was made, the sides were sheeted by horizontal 2x6-in. planks put in by well digger's methods and secured by cleats at their abutting ends. The voids behind them were immediately filled with mortar to prevent the initial movement in the outside sand. When the excavation reached ground water level, about 20 ft. below the basement floor, this method of sheeting could no longer be continued and was superseded by the use of United States steel sheet piles in 5-ft. lengths forming a 4x6-ft. cofferdam.

The piles were satisfactoritly driven by a hand hammer such as is used for driving wells and test pipes. It had a light vertical framework with guides about 15 ft. long for a 200-lb. hammer raised by a hand windlass operated by two men. The hammer frame was taken apart, brought to the pit through the narrow opening and reassembled under the wall. After the steel piles were driven, the space between them was excavated to a depth of 4 ft. without pumping, and the concrete carefully deposited in it under water, thus carrying the new footing down to the required level below the subway excavation. Subsequently the entire pit was filled with concrete up to the bottom of the old footing, the sheeting remaining permanently in the ground and serving as a form for the new footing. It is thought that this is the first instance where steel sheet piles have been driven by a pile driving machine under the walls of the building.

Piers substantially like that here described have been underpinned in the same manner at intervals of about 15 ft. for a length of nearly half a mile where the subway excavation falls below the footings of the buildings in this street.

In some places where the sidewalk is carried by 20x20-in. brick piers adjacent to the subway excavation, underpinning is avoided by an ingenious construction of concrete semi-arches, 20 in. thick and 12 in. deep at the crown, sprung from skewbacks cut on adjacent pier footings 16 ft. apart in the clear which have been carried down to the bottom of the subway excavation. The semi-arches meet on the foot of the brick pier which is beveled slightly and practically forms a key completing the arch. This arrangement transfers the moderate load on the pier to the adjacent abutments, avoids separate underpinning piers and is easily and quickly constructed, care being taken to build them early enough to insure that the concrete in them is well set before the excavation is made under them.

The work is being executed under the direction of the Rapid Transit Railroad Commission, Mr. G. S. Rice, chief engineer. The Rapid Transit Subway Construction Co. is the general contractor, Mr. George H. Pegram being the chief engineer. Cranford & McNamee are the sub-contractors, and the work is done under the personal supervision of Mr. F. S. Cranford, Mr. R. N. Cranford and Mr. J. C. Meem, chief engineer.

Drainage for Agricultural Improvement is receiving much attention in the South. The office of irrigation and drainage investigations of the U. S. Department of Agriculture is studying the Everglades, the Black Bayou in the Yazoo Delta, District of Mississippi, and the country along the Little Forked Deer River in Tennessee, in order to devise plans for draining these areas. Drainage maps are being prepared of a score of localities, and the general soil, topographic and hydrographic conditions are being studied. The Missouri Pacific Ry. Co. recently provided a special train for lecturers from this office and the office of Public Roads, to make a circuit of farmers' institutes in the towns along its lines in Arkansas and Louisiana, where there are extensive areas of marsh and swamp land. The Charleston County Sanitary and Drainage Commission during the past year has been co-operating with the Department of Agriculture in the preparation of plans for the drainage of swamp lands in the vicinity of Charleston, S. C., and the legislatures of both Arkansas and South Carolina have invited representatives of the Department of Agriculture to address them on the general subject of drainage improvement.

The Herbivora Building in the Cincinnati Zoological Garden.

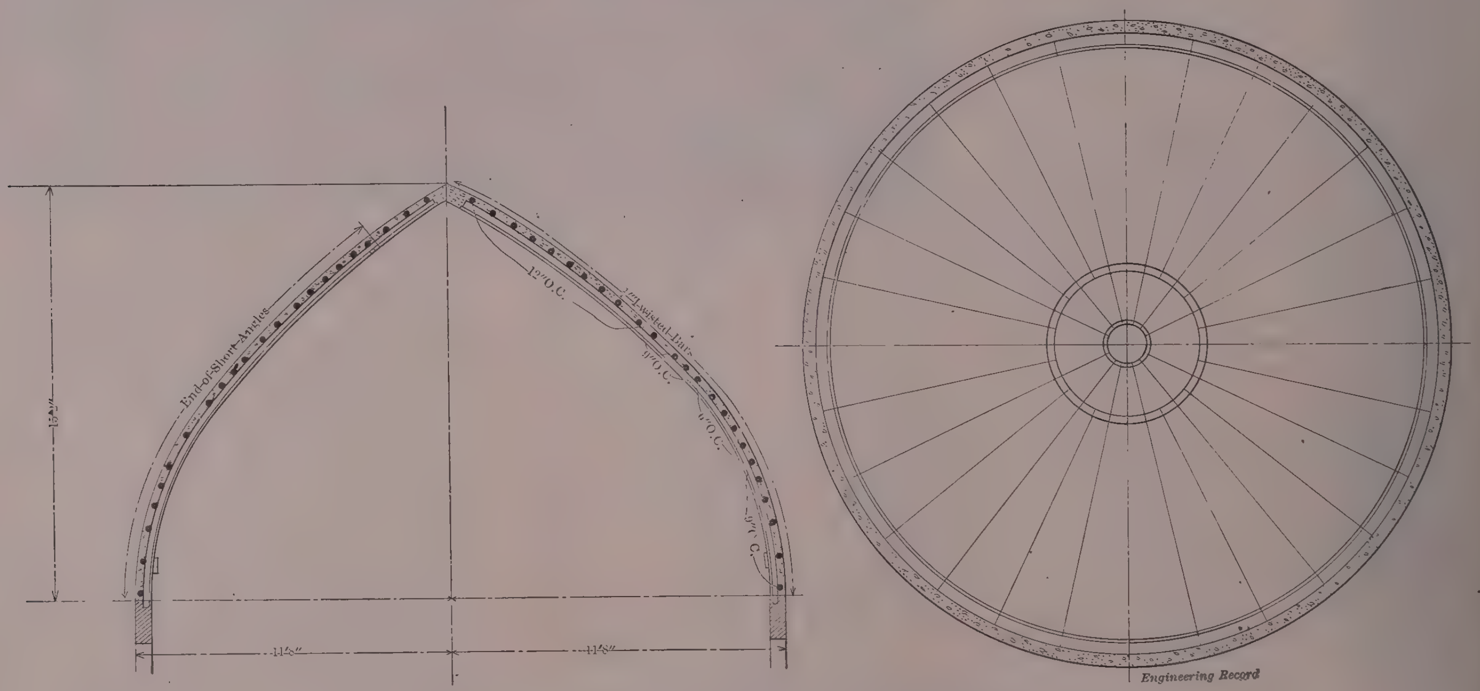
A reinforced-concrete building embracing a number of special features of design has recently been completed in the Zoological Garden in Cincinnati. This garden is controlled by private enterprise and contains a very extensive collection of animals, the new building having been erected to house the larger herbivora. The structure is 76 ft. 10 in. x 155 ft. in plan and one story high, and has a row of five domes surmounting the central one of three longitudinal bays into which it is divided. The entrances to the building for visitors are at both ends of the central bay, which is 24 ft. wide and is flanked on each side by a bay 26 ft. wide in which the stalls for the animals are placed. The largest animals are in stalls in the same side bay, these stalls being extended out to the center line of a row of roof columns along that side. The smaller animals are in stalls in the other side bay, this row of stalls extending only to within 5.5 ft. of the center line of the roof columns on that side. A passageway 5 ft. wide, extends the length of the building back of both rows of stalls, and connects with feed rooms at both ends of both rooms. The stalls are all built with concrete floors which slope back from a curb at the front, 2 ft. high above the floor of the central bay, to a drain along the passageway; a curb is also built along each side between the stalls. The stalls for the semi-aquatic animals, like the hoppopotamus, contain large water tanks, also built of concrete, below the level of the floor. The enclosures of the stalls and the partitions between the latter are heavy iron railings set in the concrete, with the exception of the stall for the elephant, which has concrete walls 8 ft. high on both sides and the rear. Each of the stalls is connected through a door in the wall back of it with the outside, the animals having out-door fenced enclosures in which they are confined during the warmer months.

Interior of Herbivora Building.

The two side walls of the building are concrete slabs, 6 in. thick, each of these walls containing a row of 18x18-in. reinforced-concrete roof columns, spaced 24 ft. apart on centers. The wall slabs are reinforced with horizontal and vertical rows of ¼-in. bars, spaced 12 in. apart on centers in both directions and placed at the center of the slab. The end wall slabs are of varying thickness, depending on the span and are reinforced the same as those of the side walls, this reinforcement being provided to prevent temperature and settlement cracks. The columns are built on spread reinforced-concrete footings. They are reinforced with a vertical ⅞-in. square bar in each corner and with horizontal ¼-in. hoops 12 in. apart on centers. The roof over the side bays is a concrete slab, 3½ in. thick, which is reinforced with ¼-in. square bars, 5 in. on centers in the direction of the span and 15 in. on centers in the opposite direction. It is carried directly by 6x20-in. transverse beams spaced 8 ft. apart on centers. These beams are carried at the outer end by 10x38-in. girders between the wall columns, and at the inner end by girders between the columns of the row on each side of the central bay of the building.

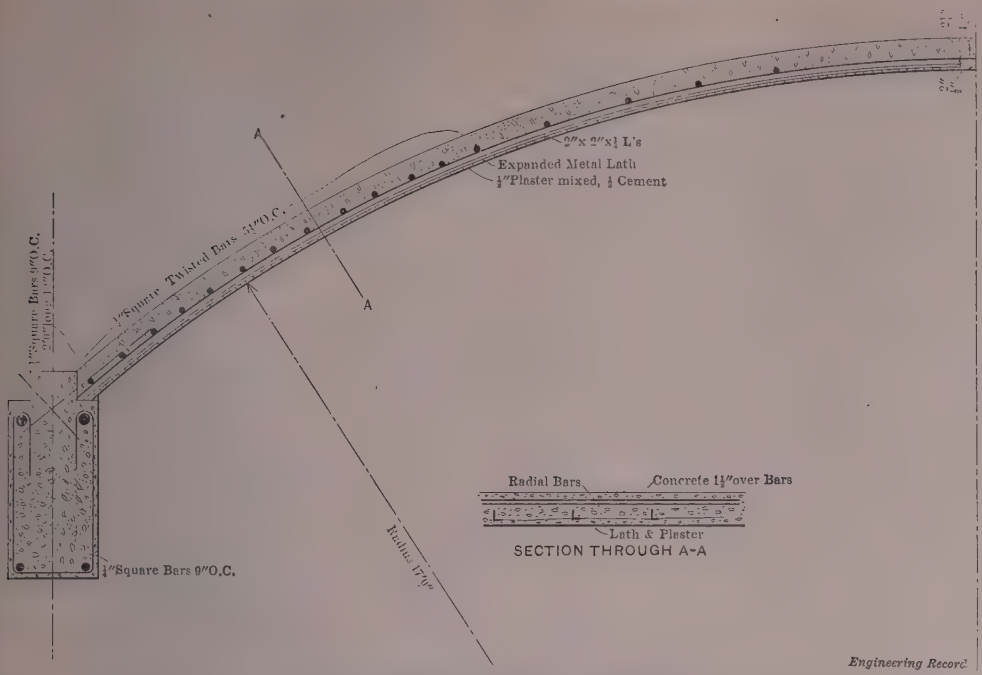
The rows of columns along the sides of the central bays are 24 ft. apart on centers in both directions, forming a row of five 24x24-ft. roof panels. Each of these panels is surmounted by a low dome built entirely by reinforced concrete, without any beams or girders. A circular dome rising to a height of 68 ft. 2 in. above the floor is superimposed on the low dome over the central bay. The square bases of the low domes are each carried on all four sides by arched reinforced-concrete girders extending transversely and longitudinally between the two rows of columns and having the latter as abutments.

The accompanying half cross-section of one of the low domes at the transverse center line of the arch girder shows the details of the latter and of the shell of the dome. The arches on the ends and sides of the two end domes and the sides of the two second domes are 8 in. thick and 6 ft. deep. They contain two longitudinal, twisted, square ¾-in. bars near the top and two near the bottom, which are placed as shown in the section and are tied together with vertical hoops consisting of ¼-in. rods spaced 9 in. apart on centers. The arch girder between the bases of the first and second dome from each end is 14 in. wide and 2.75 ft. deep, and contains four 1-in. bars spaced apart and attached together the same as in the first case. The arches between the bases of each of the two second domes and the base of the central dome has the same cross-section and is reinforced in the same manner as the second case, with the exception that it has three 1-in. bars near its extrados. The arch on each side of the base of central dome is 14 in. thick and 6 ft. deep with the same amount and arrangement of reinforcement as in the second case.



Details of High Dome of Herbivora Building, Cincinnati Zoological Gardens.

The shell of the dome has a total thickness of 4¾ in., consisting of 4¼ in. of concrete coated on the inside with ½ in. of plaster laid on expanded metal. The frame of the reinforcement of the dome consists of forty-eight 2x2x¼-in. steel angles radiating from the center of the dome. Half of these angles are attached to a 20x20x¼-in. steel plate at the center of the dome and extend to the edges of the latter. The other half are attached to a numerous-sided polygon, with its sides made of 2x¼-in. bars, which has a circumscribed circle 4.5 ft. in diameter that is placed concentric with the plate at the center of the dome, the angles also extending to the edges of the dome from it and alternating with the longer angles. The expanded metal is wired to the angles. The latter also carry numerous ½-in. square twisted bars which are bent into circular shape and are placed horizontally and concentrically in the shell of the dome, as shown in the illustration. The portions of the shell of the dome in the corners of the square are also reinforced with ½-in. circular bars, which are



Half Cross-Section of Low Domes.

The Herbivora Building in the Cincinnati Zoological Gardens.

placed as arcs of circles concentric with the other circular bars.

The base of the high dome superimposed on the low central dome was brought to a circle without the use of beams or girders. A vertical section of the base with four sides was first built on four arches forming the square panel, and on this was placed a second section with eight sides, the spaces in the angles between the sides being filled out where necessary to relieve the interior appearance. On the eight-sided section was erected a third section with 12 sides, which was surmounted in turn by a circular section forming the base of the high central dome.

The details of the shell of the superimposed dome are very similar to those of the low domes. The shell has a total thickness of 4 in. and is plastered on the inside with two coats of plaster laid on expanded metal lath wired to the frame of twenty-eight 2x2x¼-in. radial angles which form the main reinforcement for the shell of the dome. Sixteen of these angles are attached to and radiate from a ring, 1 ft. in diameter and made of a ⅜x2-in. bar, which is placed at the center of the dome; the remainder are attached to and radiate from a 6-ft. ring of the same size bar, placed concentrically with the smaller ring. All the angles are attached near their outer ends to a third ring also made of a ⅜x2-in. bar. The circular reinforcement of the shell consists of ½-in. twisted square bars spaced as shown in the accompanying cross section.

The construction of the domes was handled very readily without the use of any temporary forms whatever for the shells. The metal reinforcement was first assembled in place, the angles being securely set on the forms for the concrete base and the circular bars wired to them. The bars were lapped at least 25 in. and wired together in five places at the splices. The expanded metal lath was then attached on the under side of the angles at every 8 in. along the latter with heavy wire. Two coats of hard plaster containing one-third Portland cement were then applied to the metal lath from below, making a good form on which the concrete comprising the outside of the shell of the dome could be placed, the only centering required in the whole operation being provided for the erection of the reinforcement and for workmen who applied the plaster to the metal lath.

The concrete in the outside of the shell of the domes in the vertical sides of the base of the latter consisted of a 1:2:4 mixture of Portland cement, sand and stone screenings. As these surfaces were to be exposed to the direct force of wind and rain and were not to be covered in any manner, dependence being placd on the impermeability of the concrete to secure a tight roof, the concrete was made and laid with unusual care. A finishing coat of 1:2 Portland cement and sand mortar, containing alum and soft soap to render it waterproof was applied on the exterior of all exposed surfaces and was finished smooth with a trowel. After the building had been completed considerable difficulty was experienced with rain and melting snow leaking through the shells and bases of the domes, because the finishing coat of mortar failed to adhere to the concrete in many places and therefore cracked, thus permitting water to enter between it and the concrete. For some time it was considered that it would be necessary to cover the domes with copper, but finally the decision was made to attempt some other method of waterproofing. Accordingly, the outer 1-in. coating of the mortar on all the domes and bases was chipped off by hand, and the rough surface left after this chipping was finished was thoroughly cleaned. Then a mortar consisting of 1 part Portland cement, 2 parts sand and 2 per cent. by weight of Medusa waterproofing compound was applied. The results obtained with this coat of mortar have been entirely satisfactory, as at no time since that work was finished, about 5 months ago, has any trouble been experienced with water seeping or leaking through the surfaces thus treated, although there have been snows and long continued heavy rains during that period.

The construction of the remainder of the building involved no particular features or difficulties. The concrete was all made in the proportions of 1 part Portland cement, 2 parts sand and 4 parts broken stone, a ½-yd. Chicago cube mixer being used. After the forms had been stripped, all exposed surfaces on the interior of the building were given a wash consisting of a light cream color cold-water paint, and the base was painted maroon to a height of 6 ft., resulting in the very excellent appearance shown in one of the accompanying illustrations. The exposed exterior surfaces were given a finishing coat of mortar consisting of 1 part Portland cement with a little lime, to 2 parts fine gravel. This mortar was thrown on the surface of the concrete with a broom after that surface had been thoroughly wet. This method of finishing proved very satisfactory and relieved the dull lifeless appearance of the concrete as it came from the forms.

The building was designed by Messrs. Elzner & Anderson, architects and engineers, of Cincinnati, Ohio. The construction was carried on by the Collier Bridge Co., of Indianapolis, Ind.

The New York Connecting Railroad has at last received the official approval of the Board of Estimate and Apportionment of the City of New York, and this great undertaking can now be advanced as rapidly as the interests of the Pennsylvania Railroad Co. render it desirable. The Board has also given the company permission to make changes in a number of streets near Long Island City, where it is proposed to establish a very large freight yard. This action is one which will mean a great deal to Greater New York in the way of transportation, for it will enable the Pennsylvania Railroad Co. to run trains directly from New Jersey through Manhattan into Long Island City and thence over the connecting bridge across Hell Gate to a junction with the New York, New Haven & Hartford R. R. In other words, passengers from the West can pass through New York without any change of cars. It also means that the company's facilities for handling freight for a large part of the city and around the city will be very much improved.

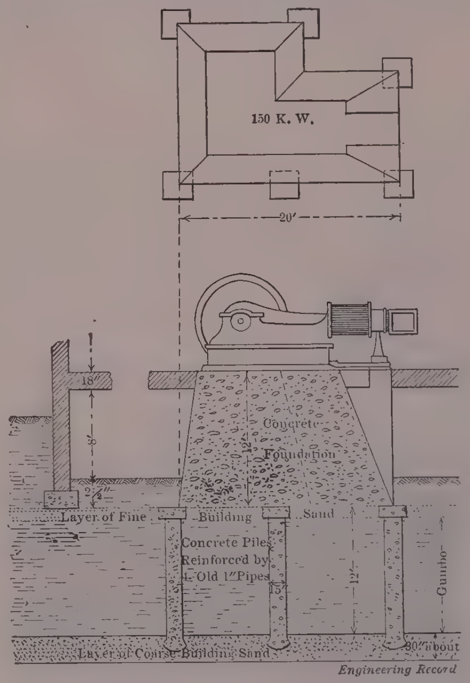
Reinforcement of Engine Foundations on Soft Soil.

The new soap manufacturing plant of the Procter & Gamble Co., at Armourdale, a suburb of Kansas City, is located on the banks of the Kaw River where unusually poor facilities for foundations were afforded. The banks of the river throughout the entire district are composed of sand and silt that has been deposited by the river in floods and are of a very soft and treacherous nature. Although the ground level at the plant is some 20 ft. above the normal stage of the river, the entire soil at this point is composed of alternate lawers of loam and quicksand, with occasional strata of sharp building sand, down to a depth below that of the river bed. The mixture, which is known locally as "gumbo" remains of a peculiar sponge-like texture and does not settle, and large sections are subject to vibration in a mass.

In the construction of the plant the foundations of the buildings were carried down from 12 to 14 ft. below the ground level to a layer of clean sharp building sand, on which the footings were spread to an unusual extent for low-bearing pressures. In the manufacturing building a group of twenty large steel tanks, weighing from 500 to 550 tons each and subject to violent vibration in boiling, are successfully carried on a continuous mattress of concrete 2 ft. in thickness and reinforced on the lower side by 2-in. twisted steel rods. In the engine room of the power plant, however, difficulty was experienced with the foundations for one 150-kw. generating and two 300-kw. units, consisting of Skinner tandem-compound engines direct-connected to Crocker-Wheeler generators. The concrete is carried down 12 ft. to the same layer of building sand to which the building footings were carried and over which they were spread for very low bearing pressures. Upon erecting the 150-kw. unit and starting the engine for a trial run, it was noted that as the engine was brought up to speed, the entire machine and foundation began to rock on the soft soil. The rocking gradually increased as the engine continued to run, the motion consisting of a movement of rocking longitudinally across the center with a vertical movement at either end of from ¼ to ½ in. As the engine was a high-speed machine and well balanced, it was evident that the stability of the soil under slight vibration had been underestimated and as the rocking became dangerous the engine was shut down.

In studying the problem of providing a suitable foundation for the engines an effort was made to ascertain the possibility of reinforcing the foundations as they had been installed, in order to avoid tearing them all out as all the foundations had been completed and the engines were being erected. For this purpose a careful examination of the underlying soil was made by digging a hole from 10 or 12 ft. below the base of the foundations in order to ascertain the bearing capacity of the underlying strata. A hole several feet in diameter was dug without difficulty, the sides of the pit standing without support, and it was found that the soil continued of the same character to a point 20 to 25 ft. below the ground level, where another layer of coarse building sand of a better quality was encountered. At the suggestion of the chief engineer of the Procter & Gamble Co., it was decided to extend footings from the corners and sides of the present foundations down to this layer of sand in an attempt to hold them rigid and avoid reconstructing them.

Excavations were made from the basement level to the sides and corners of the foundation of the 150-kw. unit and holes bored thence to points about 12 ft. below the base of the foundation until the layer of sand was encountered. The holes which was built of a stem of 2½-in. pipe with two sets of auger vanes, one 8 in. in diameter at the tip and the other 15 in. in diameter about 15 in. above the tip. At the upper end of the piping a handle of the usual type was fitted by means of which the auger could be turned into the soil and lifted out periodically, bringing large masses of the soil at a time; the auger was turned into the soil until it clogged, when it was lifted by a block and tackle, bringing up a mass 2 or 3 ft. in depth. In this way the holes were bored rapidly, and owing to the nature of the soil preserved their shape satisfactorily. In filling the holes with concrete, four pieces of 1-in. pipe were inserted for reinforcement which also served for pumping a rich mixture of cement to the bottom of the openings that spread into the sand and formed a wide bearing footing. The concrete used to form the piles was poured very rich and carefully rammed, the tops of each pile being capped with a large square block which projected for the greater part under the engine foundations. After the piles had set for several days, the blocks were carefully grouted in under the edges of the foundation so as to form an effective union.



Engineering Record

Underpinned Engine Foundations.

After allowing the piles to set fully, the engine was again started up and ran thereafter without the slightest suggestion of vibration, as a result of which similar reinforcement was carried out on the larger foundations of the two 300-kw. machines and a large cross-compound air compressor. The reinforcement proved equally satisfactorily on these three units, which have operated since without vibration. There were seven piles installed under the 150-kw. machine, as indicated in the accompanying plan, and eight under each of the 300-kw. machines and the air compressor As an evidence of the complete stability and lack of vibration, the operating engineers now find it possible to balance coins on edge on the engine while in operation which will stand for days at a time.

The chief engineer of the Procter & Gamble Co. during construction of the plant, was Mr. R. S. Woodward, Jr., New York.

The Recession of Niagara Falls has been investigated by Mr. G. K. Gilbert, of the U. S. Geological Survey from data secured in 1827, 1842, 1875, 1886, 1890 and 1895. The rate of recession of the American Falls in 78 years has been less than 3 in. annually, while that of the Horseshoe Falls has been about 5 ft. annually since 1842.

The Cobb's Hill Reservoir, Rochester, N. Y.

The 140,000,000-gal. Cobb's Hill reservoir now under construction in the southeastern part of Rochester, N. Y., for which contracts were let July 20, 1906, involves the excavation of about 800,000 cu. yd. of sand and gravel and the placing of 50,000 cu. yd. of concrete in the reservoir walls and floor. The site, covering an area of 60.371 acres, was acquired by the city at a cost of $123,500, or an average price of $2,045.68 per acre, the condemnation proceedings having been begun in 1903. The necessity for an additional distributing reservoir for the water supply of the city had long been recognized, and when Conduit No. 2 was constructed in 1894, from Hemlock Lake to Mt. Hope reservoir, a distance of about twenty-nine miles, provision was made for a 36-in. connection to the proposed new reservoir. The Mt. Hope reservoir has a capacity of 22,500,000 gal. and lies on the same range of hills as the new reservoir, 1½ miles to the west and at the same elevation. It will be used in connection with the new reservoir.

Cobb's Hill rises to a maximum height of 400 ft. above the city datum, and is composed of sand and gravel of excellent quality. The reservoir is to be scooped out of the top of this hill, the maximum cut required to secure 25 ft. of water being 50 ft. and the average about 25 ft. Two unimportant fills have been necessary, one of about 10,000 cu. yd., and the other much smaller. All the excavated material will be placed on the sixty-acre site. Some of it is to be used in filling in behind the retaining walls and the remainder is being wasted. In plan, the reservoir has the form shown in an accompanying sketch.

The concrete retaining wall is about 3,600 ft. long and is shown in cross-section in an accompanying illustration. The wall proper is built in sections 20 ft. long and rests on foundation blocks each 10 ft. long. It is covered with 5-ft. coping blocks 3 ft. wide and 1 ft. thick. The wall, including its foundation and coping, has a maximum height of 25 ft., and the base is 15 ft. 6 in. wide. A passageway, about 7 ft. high and with an average width of 3 ft. 9 in., extends throughout the entire length of the wall and permits inspection of the interior. In order to avoid a more massive base, the wall foundations have been placed higher than the general elevation of the reservoir floor. From a point 50 ft. from the toe of the wall the bottom rises on a 10 to 1 slope to the foot of the wall, as shown in the illustration. The top of the foundation blocks also have a slope of 10 to 1 toward the reservoir and the wall blocks are guarded from a tendency to slip by a broad concrete key projecting into a seat in the foundation blocks.

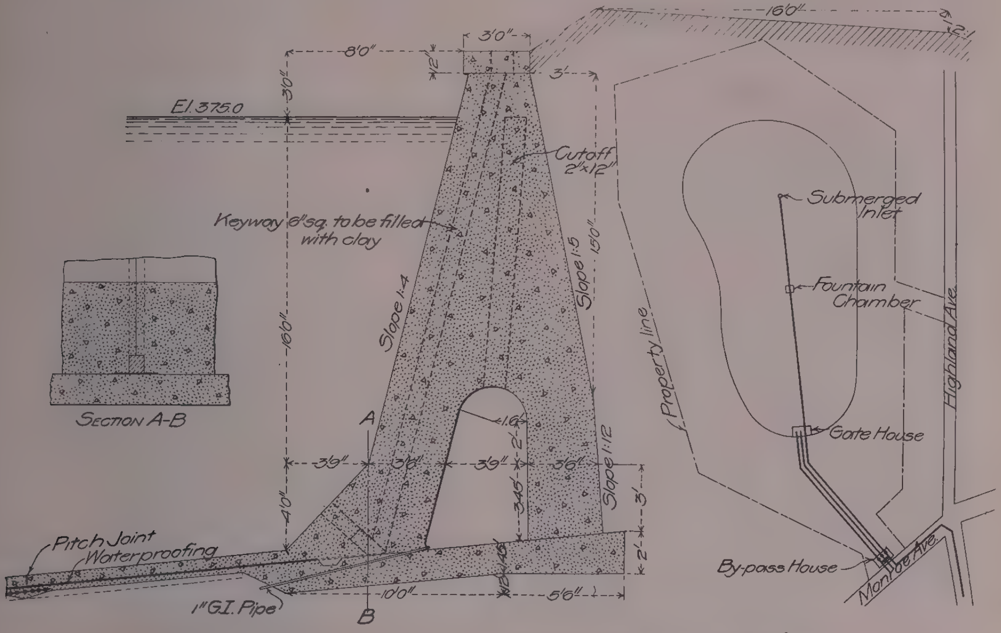
The following are extracts from the specifications under which the concrete work is being done.

"*Sand.*—The sand used for concrete shall be selected by the contractor from the excavation, or the excavated material, and shall be subject to the approval of the engineer. It must, when used, be free from more than 7 per cent. of clay, loam or other foreign matter, and shall be coarse and sharp. All pebbles shall be excluded which do not pass freely through a sieve of 4 x 4 meshes per square inch. Sand for mortar for brick masonry, or for laying cut stone or coping stones, shall pass through a sieve of 10 x 10 meshes per square inch."

"*Gravel.*—The ballast used in concrete masonry shall be clean Cobb's Hill gravel which will not pass through a sieve of 4 x 4 meshes per square inch. It shall be classified as follows: No. 1, in which the largest stones shall pass through a 1-in. ring. No. 2, in which the largest stones shall pass through a 2-in. ring and which were bored by an improvised post hole auger shall contain 25 per cent. by bulk of No. 1.”

Class	Cement	Sand	No. 1 Gravel	No 2 Gravel
A	1	2	4	
B	1	2½	5	
C	1	2½		5
D	1	3	6	
E	1	3		6

“Class A concrete will be used for the body of coping stones, flagstones and in other places designated by the engineer. Class B concrete will be used in the thinner walls of the houses and in floors, or wherever steel reinforcement is used; also in the upper slabs upon the reservoir bottom and in other places designated by the engineer. Class C concrete will be used in the thicker walls of gate houses, in the reservoir wall, in the walls of the fountain and in other places designated by the engineer. Class D concrete will be used in the lower layer of the reservoir bottom, in piers and pedestals for supporting pipes, gates and special castings, and in other places designated by the engineer. Class E concrete will be used in the foundation of the reservoir wall, in the foundation of the gate houses and fountain, in the shaft supporting the vertical end of the main inlet pipe and in other places designated by the engineer. But one price will be bid for concrete and this shall be understood to be for Class B and Class C. Class A will be paid for at a rate 8 per cent. greater than the bid price, and Class D and Class E at 4 per cent. less. The engineer may change the class to be used on any part of the work to any extent, and the payment shall be upon the class used.”



Cross-Section of Wall. and General Plan of Reservoir.

The embankment immediately behind the retaining wall is to be carried up in 4-in. layers, compacted by sprinkling and rolling with a grooved roller, and will in general not extend beyond the rear angle of the wall. Further back the material is to be dumped on a slope not sharper than 2 to 1, and the dump will be carried up at the same time as the rolled bank. The wall is designed to be stable under the three possible conditions. With the reservoir full of water and the earth backing in place, the resultant falls near the center of the base; when the reservoir is empty it is still within the middle third; and with the reservoir full and no pressure from the earth backing it falls just within the heel of the base.

The wall foundation is laid in alternate blocks, and the intervening spaces are filled in later. The wall blocks are built in the same manner, as may be seen in an accompanying illustration. All curves of the bank are followed by the foundation and wall blocks with 10-ft. and 20-ft. chords, respectively, thus avoiding curved forms. The coping blocks are laid in 5-ft. chords on a parallel curve. The joints between the wall blocks are to be made tight by a stop water of finely pulverized clay, puddled into a key-way extending from top to bottom of the wall 1 ft back of the face. This key-way is 6 to 8 in. square and is placed diagonally with the plane of the joint. Back of this, in the center of the wall, the contiguous blocks have at each joint, a vertical groove in one and a corresponding projection on the other 12 in. wide and 2 in. deep, which is designed to check any flow of clay through the joint. The coping blocks, break joints over the wall joints and in every fourth coping block is an opening 1 ft. square through which the clay can be introduced into the key-way, or if necessary removed with a post-hole auger. A concrete cover 1 ft. square with a flush handle is to be used to close these openings, concrete being considered cheaper and more sightly for this purpose than metal, besides being proof against corrosion. At the bottom of the main key-way it is intersected by another 8-in. square which runs out to the face of the wall. This will be used as a clean-out for the main key-way before the clay is introduced and then will be closed with concrete.

Filling the Wall Block Forms.

The front face of the wall blocks is to be waterproofed with a wash, applied immediately after the removal of the forms and consisting of a neat cement grout to which has been added 5 lb. of potassium alum and 1 lb. of concentrated lye for each bag of cement, the whole being mixed to the consistency of whitewash. Three coats are to be applied, each coat being rubbed with a block of sandstone until it lathers freely before another coat is added. This waterproofing is applied to prevent scaling of the face of the wall by frost near the water surface, rather than to check leakage through the wall.

The floor of the reservoir will consist of three layers. The bottom one will be a continuous sheet of concrete, in general 3 in. thick. This will be covered with a waterproofing material consisting of five layers of single-ply coal tar felt, each mopped with hot coal tar pitch above and below. This in turn will be covered with blocks of concrete 12 ft. square and 6 in. thick. The concrete in these slabs will be laid and tamped in 3-in. layers until the whole mass is consolidated. The under layer of concrete is made thin with the expectation that it will develop many small temperature cracks. Before the design of the floor was finally adopted, experiments were conducted to determine the effect of the changing temperature of the water on the material of the bottom. The experiments indicated that the lower layer would tend to fault under the joints of the 6-in. layer, hence the lower sheet has been made 6 in. thick under all the joints, and is also reinforced with metal across the joint lines. This reinforcement consists of ¼-in. round steel bent in loops as shown in the foundation plan. The successive crossings of the rod are 4 in. center to center and the loops are 2 ft. long. This is placed about 2 in. below the upper surface of the 3-in. layer and gives double strength where corners of four of the surface blocks come together.

The 12-ft. slabs are first to be laid alternately in alternate rows. Then the remaining blocks will be laid in the rows first begun. Then blocks will be laid in the intervening rows contiguous to those first made and finally these rows will be completed by filling in the remaining spaces. In the lower half of the joints the blocks will be separated with one thickness of single-ply coal tar felt, but the upper half is to be held open by a form, 3 in. deep, ½ in. wide at the top and sloping to ¼ in. at the bottom. When this form is removed, the space left will be poured full of hot coal tar pitch.

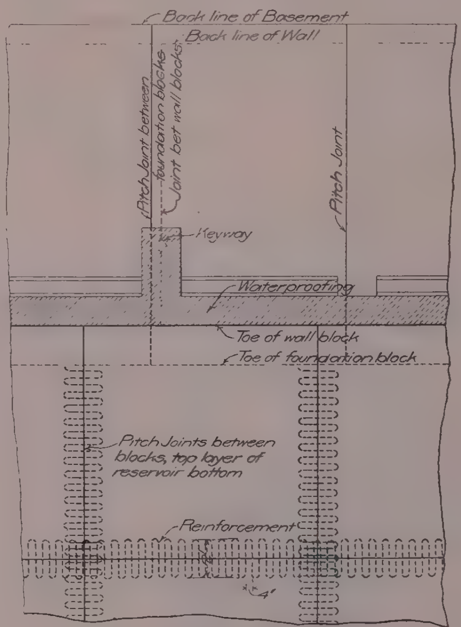
The five-ply waterproofing layer is to be carried under the toe of the wall blocks, and where the key-ways occur a strip of waterproofing 2 ft. wide will be run back still further under the keyway, to make the waterproofing continuous. Where the floor joins the front edge of the wall blocks, there is a joint like that between the floor slabs. A similar joint is made between the contiguous wall foundation blocks. It is expected that if a break occurs, it will appear at the front edge of the foundation blocks where the bottom joins the heavy wall blocks. In order to make it possible to locate a leak of this kind, a 1-in. galvanized iron tell-tale pipe is to be placed under each wall block, running from the soil under the toe of the wall through the foundation blocks into the inspection passage. The seepage from these pipes will pass over a waste weir in the gate house and when the flow is seen to increase the pipes from which the added leakage comes can be located, and a temporary repair made by dumping clay in front of the wall and tamping it in place.

The reservoir will be supplied by a 36-in. cast-iron pipe conduit about 7,000 ft. long which has been constructed in Clinton Ave., S., Highland Ave. and Monroe Ave., leading from the connection with Conduit II. Two 36-in. mains will connect the reservoir with the city distribution system. A concrete and brick by-pass house is being erected at the foot of the hill on the Monroe Ave. side. This contains three 36-in. guard gates and two 24-in. gates by means of which the water from the conduit may be by-passed directly to the city without entering the reservoir. These gates have rising stems and were supplied by the Rensselaer Manufacturing Co. From the by-pass house, the three pipes are laid to the gate house, 638 ft. to the eastward, rising 72.4 ft. in that distance, with a maximum grade of about 18 per cent. In hauling the pipes up this hill and placing them in the trench, a Byers portable hoisting engine was used. The gate house proper will be located at the west end of the reservoir. The substructure, which will contain the gate chamber screen wells, and overflow chamber, is to be constructed in the embankment and will form a portion of the reservoir wall. The central passage through the retaining wall will terminate at the gate house. The gate house is to contain three hydraulically operated 36-in. Rensselaer gates, two screen wells with a gross screen area of about 144 sq. ft., and an overflow weir with a 12-ft. crest. The Rensselaer gates are specially designed so that by throwing in a clutch they may be operated manually when necessary. The substructure of the by-pass house and gate house will be built of concrete, the walls being massive and the floors reinforced.

The inlet conduit will pass through the gate house and along the reservoir bottom to a fountain chamber in the center of the basin, in which will be placed, just beyond the fountain branch, a 36-in. gate hydraulically operated from the gate house. The conduit will extend from this gate about 400 ft. further to a submerged inlet, which will discharge 5 ft. below high-water level. It is intended to admit the water through the fountain in the summer and through the submerged inlet in the winter. Circulation is assured since the outlet is at the west end of the reservoir through submerged sluice gate openings in the front wall of the gate house to the screen wells. The overflow chamber is drained by a 36-in. cast-iron pipe 3,000 ft. long, which discharges into the Erie Canal 133 ft. below the reservoir. By operating a sluice gate, the reservoir can be washed out and slushed into this waste pipe. All the pipes, valves and operating mechanism were furnished and delivered on the site by the city.

At present all excavation and concrete work, except the foundations of the by-pass house which is under cover, has stopped for the winter, and the wall blocks that have been built have been fitted with doors over the ends of the passage-way which is now being used for storage room. The bulk of the excavation has been done with a 70-ton Bucyrus and a 50-ton Thew shovel, both of which are now on the work. The shovels and other equipment were brought in with difficulty since it was necessary to take them up the hill behind the by-pass house and part of the way around a very sharp curve. In connection with these shovels 12-yd., side-dump, standard-gauge, Western Wheel Scraper Co. cars are used. They are handled by a 33-ton "Shay" geared locomotive, made by the Lima Locomotive & Machine Co., Lima, O. A 25-ton engine formerly in service on the Manhattan Elevated R. R. in New York City is used to spot cars and serve the smaller shovel.

The site was first cleared of brush, roots and stumps and the top soil was stripped off with an elevating grading machine, drawn by a traction engine, delivering to wagons and with scrapers, and was placed in storage banks from which the best loam will be taken for use as a top dressing for the completed embankments. In beginning the excavation proper, a trench was first cut with the shovel along the south side of the reservoir in which tracks were laid for the shovel and cars. Work was then carried on by shifting the tracks over and taking cuts along the north side. During the greater part of the summer and fall two 9-hr. shifts were worked each day, thirty-two candle-power electric lamps being used to light the work at night. The wasted material has been disposed of mainly in the deep pit on the north side. The side of the pit nearest to the reservoir has a slope of about 1 to 1. The embankment along it is formed by depositing the material from a track about at right angles to the steep face of the pit so that any settlement or sliding of material will not be away from the reservoir. The length of track projecting over the deep pit varies from 150 to 300 ft. As the embankment thus formed has a height of over 100 ft., care has to be used in handling it. The material settles to a slope of about 1½ to 1. The settlement takes place constantly and averages, when the work is in progress, about 6 in. between trains, and the track has to be jacked up and tamped continually. The 12-yd. standard-gauge cars have been very satisfactory for this work since it has not been necessary to lock them to the track and the shovel has been able to work almost continuously. They are equipped with automatic couplers which further facilitate rapid handling. The maximum estimated quantity of material excavated in one month was 69,000 cu. yd.



Plan of Walls and Floor.

All the sand and gravel used in concrete is found on the site. At first it was thought necessary to separate the two, but this has been discontinued and the unscreened gravel has been mixed with the cement in the proportion of 6 to 1. This is equivalent to the 1:2½:5 mixture required by the specifications and gives a slight excess of cement. While the bank run was being used, the gravel was tested daily. For this purpose vessels were used which were so proportioned and graduated that the percent. of voids was determined without calculation. The cement used is Alsen's American. It is brought in on a switch track which leads through a storage shed having sixteen rooms on each side, each room large enough for a car load. The total storage capacity of the building is therefore, 6,400 bbl.

The concrete mixing plant is located at the east end of the reservoir. A Hains mixer is mounted in a wooden tower, as shown in an accompanying illustration. The sand and gravel is brought up in drag scrapers and dumped through a rack which takes out the large stones. It falls on an inclined plane and slides out where it can be picked up by a clamshell bucket operated by a stiff-leg derrick and a Lambert hoisting engine. It is lifted to the upper platform of the tower and deposited in a hopper from which it may be admitted to the four hoppers of the mixer on the platform below, where the cement is added. From the mixer, the concrete is delivered to Cyclopean buckets on a car below. The cars on which these buckets are hauled were made by building platforms over the trucks of locomotive tenders and five 1-yd. buckets are handled on one car. A Davenport 18-ton locomotive is used in connection with the concrete plant.

Each wall block contains 106 cu. yd. of concrete and in some cases a block has been made in 7 hours. Five forms have been used, but ten more are being built and the contractor expects to make two blocks per day next summer. The forms are made of 2-in. plank and are lined with coal tar felt, covered with galvanized iron, thus making them water tight and avoiding joining the plank ing tightly. The vertical supports are wooden trusses which are seen in an illustration. In building isolated blocks end forms are necessary, but when the intermediate blocks are made their face forms lap over the concrete faces of the blocks already in place and the joint is calked with oakum and clay. The face forms are securely bolted together and are also attached to the foundation blocks with six 1-in. bolts since, when they are filled with concrete which is mixed quite wet, they are subjected to a hydraulic head of over 20 ft. and any movement means leakage of water and cement. So far only one form has lifted. This was due to a cracked sleeve nut and occurred during the making of block No 13.

In delivering the concrete from the cars to the forms, a McMyler locomotive derrick is used. A special arrangement has been devised which avoids a sudden discharge of the bucket and makes it unnecessary to employ a man to trip it. A chain passing through the ring in the bucket bail is attached to the door of the bucket and the weight is carried by this chain till the bucket is over the forms. The weight is then gradually transferred to another chain attached to the bail and the door opens. On the top of each wall block form are two steel hoppers one near each end. The spout of each hopper is divided into two branches to each of which is attached a canvas leg and the two straddle the form which occupies the passageway space. As the concrete rises the legs are rolled up and when the form is full they are unhooked and cleaned with a hose. So far about 280 lin. ft. of wall has been built, not including five intermediate spaces which have been left open. Practically no floor concrete has been laid, except a little along the toe of the wall blocks. In delivering the floor concrete 1¼-yd. steel side-dump cars made by Arthur Koppel, of New York, and drawn by horses, will be used. It is not expected that the concrete mixing plant will be moved from its present position during the progress of the work. A novel feature of the work is a wooden tower about 40 ft. high, which has been erected near the west end of the reservoir and from which general progress photographs are taken monthly.

Waste Dump, 100 Feet High, Cobb's Hill Reservoir.

The estimated quantities of material and labor and the prices bid on them are as follows: 800,000 cu. yd. of earth excavation, at 17 cents; 80,000 cu. yd. rolled embankment, at 30 cents; replacing 40,000 cu. yd. of top soil, at 20 cents; 50,000 cu. yd. of concrete masonry, at $3.59; 2,700 squares of alum and lye waterproofing, at $3 per square per coat; 7,900 squares of coal tar pitch waterproofing, at $2.70 per square; 2,000 sq. ft. of Portland cement flagstone walk, at 20 cents per square foot; 67,000 lb. of steel reinforcement, at 2½ cents; 55,000 lb. of steel and iron work, at 6 cents; setting pipes, special castings and valves, 850 tons at $10 per ton. The total price bid is $390,805.

The work is under the general charge of Mr. E. A. Fisher, city engineer. Mr. John F. Skinner as principal assistant engineer made the general and detailed plans for the work. Mr. Frederic P. Stearns, chief engineer of the Metropolitan Water & Sewerage Board of Boston, Mass., was retained as consulting engineer in the preparation of the plans and specifications. Mr Willard D. Lockwood was the resident engineer in charge of construction during last year, but as he resigned to take another position the vacancy was filled by Mr. Archibald J. Grant. The general contract was awarded to Denniston & Co , of Rochester, who sub-let the excavation work to the Burghard-Wise Construction Co., of Buffalo. Mr. Geo. Holler is superintendent for the Denniston Co., and Mr. Houston Barnard is superintendent for the Burghard-Wise Construction Co. The 36-in. pipe for the connection conduit was supplied by the Camden Iron Works at $25.20 per net ton, and was laid by H. B. Hooker & Son, of Rochester.

The Flow of Steam Through Orifices.

The flow of steam through orifices has been investigated by Mr. D. S. Jacobus, of the engineering staff of the Babcock & Wilcox Co. He inserted a plate with 3/8-in. holes bored in it in a flange union in a 2-in. pipe. There was a single hole in the center of the plate and five on the circumference of a circle midway between the periphery of the central hole and the surface of the pipe. The flow per hole was about 14 per cent. greater in this case than with a single central hole, showing that the conditions on the exhaust side of such a plate are important. It was also found that the pressure on the exhaust side of the plate varied considerably at different distances from it. The pressure used on the high-pressure side was 147 lb. and on the exhaust side 105 lb., the latter being measured at a considerable distance from the plate in order to avoid a jet action which existed at a point near the plate and caused a lower pressure there than farther out.

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No.
Concrete Mixing Plant at Cobb's Hill Reservoir.

The Abuse of Drawbridges.

The drawbridge is of such manifest usefulness in permitting navigation where a fixed bridge would prevent it, that there is something of a tendency to consider the mere presence of a draw span in a bridge as prima facie evidence and absolute proof of the precedence that vessels should have over trains. The modern movable span is an engineering work of much technical merit, deserving high praise, but its presence along the line of a road subject to heavy traffic at certain times of the day causes such great inconvenience that whenever one is put in service there should be regulations drawn up by the federal authorities at the same time regarding the periods when it can be opened. There are several of these bridges over the Passaic and Hackensack rivers in New Jersey, for example, which on no account should be opened during the periods of heavy suburban traffic. The boats using these streams are mainly small material barges, with an occasional lumber schooner; yet to give them passage the train movements on three railroads are often thrown into confusion, and the time of the passengers which is thus lost is probably collectively worth much more than the cargoes of the boats. The roads using these bridges handle the most important suburban business out of New York, and it is an injustice to the roads and to the people living along them and doing business in New York to be held up from ten minutes to half an hour in order that a few bricks or a little lumber may be delivered somewhere along the rivers. The rush period on the railways is not a long one in the morning or afternoon, leaving most of the day and all of the night free for navigation, and it is simply justice in such a case to close the draw spans by federal order at times when trains are most frequent.

THE PARK EXPENDITURE of Cambridge, Mass., for the year ending Nov. 31, 1906, is given in the annual report of the Board of Park Commissioners as $14,721.78 for construction, and $45,390.29 for maintenance. Of the latter sum no less than $14,000 was expended in exterminating the brown tail moth. In this work besides caring for trees in parks and streets the Park Department cleaned the trees in private estates, charging for the work at the rate of 25 cents per hour. The elm leaf beetle also became a pest last season, doing much damage to the foliage.

The Power Plant of the Spokane & Inland Empire R. R. Co.

By Wm. F. Zimmermann, Consulting Engineer.

Some two years ago or more Mr. Jay P. Graves and associates decided to enter the electric light, heat and power field in the city of Spokane in connection with their traction business, at that time in its infancy. Accordingly, they had all the available power sites of any reasonable size and within a reasonable distance of Spokane examined. The engineer making this examination reported that, everything considered, the site now being developed was the best that could be had, and steps were immediately taken to acquire the property.

The site selected was about ten miles down the Spokane River from the city of Spokane and at a point where the river cuts through a deep granite rock gorge. It so happened that at this point the surface of the river at high water was about 320 ft. wide, while at low water the channel was on the west side of the river about 100 ft. wide and approximately 20 ft. deep, while on the east side of the river there was a rock bottom approximately 200 ft. wide, which stood above the water at low water. This made an ideal location, inasmuch as the power house could be placed in the deep part of the stream and the dam, which would have to be about 225 ft. on the crest, could be built practically on dry rock. The canyon was deep enough so that a dam 60 ft. high could be built and at the highest water not overflow the rock contour. By building a dam of this height, a lake was created about 4½ miles long, having a superficial area of about 400 acres, the advantage of such a development, of course, being that with the storage capacity, a peak load on the power plant can be handled at least twice as large as the normal flow of the river would admit without storage.

Having acquired the necessary property, Mr. Graves and his associates decided in April, 1906, to proceed with this development and transferred the property to the Spokane & Inland Empire Railroad Co., and this company employed the firm of Messrs. Sanderson & Porter to be designing and constructing engineers, and made arrangements with the writer to enter the employ of the Spokane & Inland Empire Railroad Co. and to act as consulting engineer for this work. Accordingly, plans were immediately made and the work started about July 1, 1906.

The work was started by preparing the rock on the east side of the river for the reception of the dam, carrying on at the same time the coffer work to divert the water from the deep part of the river on the west side, so that the power house could be built before the construction of the dam was commenced. The design admits of passing the water through the draft tubes while the dam is being erected. Granite rock, a fine quality of gravel and a fine quality of sand were found on the side hills and within a few hundred yards of the work, thus making ideal conditions for concrete and cyclopean work. The cofferdams were built largely of timer cut off the land to be flooded, and the water was stopped out by means of log mats covered with hemlock boughs and sealed with fine sand and gravel, put in position by hydraulic jets. The concrete plant, having a mixing capacity of 500 cu. yd. or more a day, was located on the east side at an elevation above that of the dam crest and directly below the sand and gravel pits, so that the sand reaches the sand bins by gravity, and the gravel is hydrauliced so as to be properly washed into a screen, which screen in turn delivers it to the gravel bin. The gravel is of a very fine quality, and the concrete mixture now being used is one, two and five. The machine shop, steam plant and camp is located on the bench or plateau on the west side of the development. The camp is large enough to accommodate about 350 employees; special buildings were built for the engineers, the foremen and the workmen, and the mess house is arranged so that the foremen have their meals in a separate room from the workmen.

The centrifugal pumps are used to keep the interior of the cofferdam dry. At each corner of the rectangle forming the cofferdam is located a jib crane with hoists, and these four cranes cover the entire power house site. Spoil banks are made along the sides of the river so that the excavated material is drawn as short a distance as possible. A large amount of material is also dumped into the river just above the up-stream coffers.

Concrete Plant and Excavation for Tail Race and Power House.

The power house is approximately 110 ft. across the stream, 87 ft. high from low-water mark and approximately 85 ft. from the up-stream walls of the power house to the down-stream walls. The power house is designed to accommodate four units of 5,000 h.-p. each, the initial installation being two such units. The wheel pits are open flumes closed by head gates, each unit consisting of four 42-in. adjustable bucket wheels built by the Holyoke Machine Co. of Holyoke, Mass. The shaft of these wheels runs directly through the dam wall and is connected by a flange coupling to a 3,750-kw. three-phase, 2,200-volt, 60-cycle alternator, the shaft of which carries an exciter of sufficient size to excite three units. The turbine speed regulator is placed between the generator and the dam wall. The switchboard, electrically operated, to which nothing but the low-tension wires are connected, is placed in the center of and on the down-stream side of the power house, so that the switchboard operator will have full view of each and every machine. A traveling crane, hand operated, covers the entire length of the dynamo floor. The height of the building is such that the second floor, 30 ft. above the dynamo room floor, is used for all the switchboard apparatus, both high and low-tension switches and their connections being made on this floor.

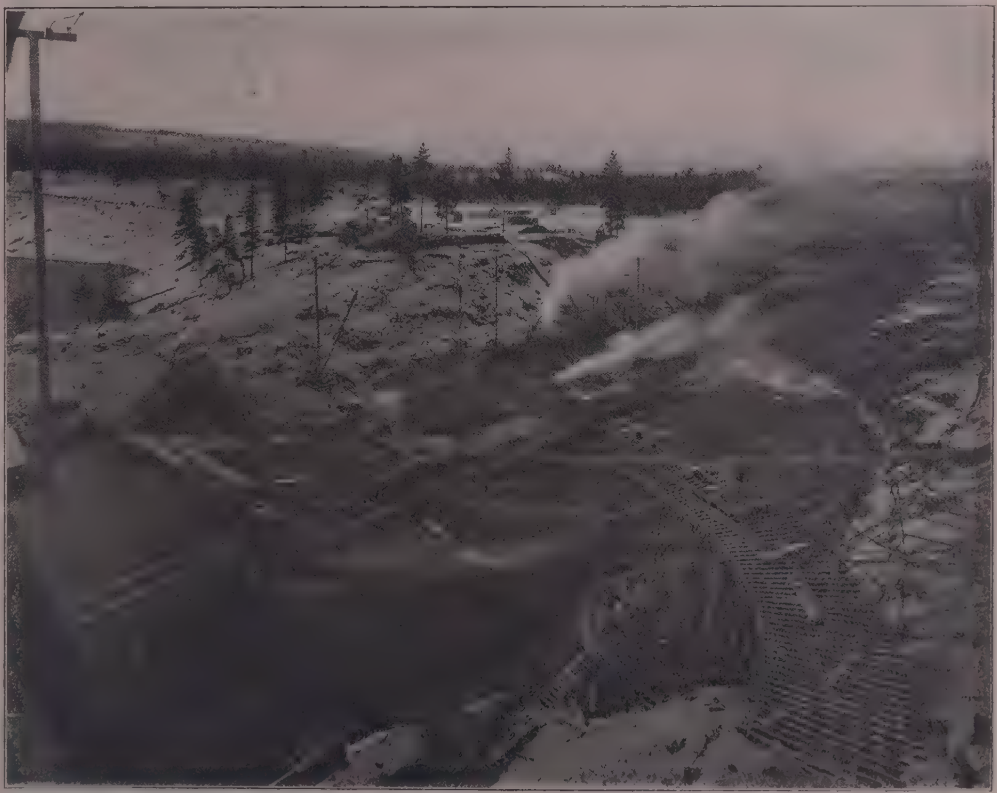
The dam wall is so constructed that the space between each set of retaining piers is used for the transformers, there being one set of raising transformers, raising the voltage from 2,200, the machine voltage, to 60,000, the line voltage adopted. These transformer rooms are built entirely of concrete, access to them being through fireproof iron doors.

The transformer rooms are drained directly to the tail-race, and the transformers have an oil drain with a valve which can be operated from the dynamo room, discharging the oil into the tail-race and to be used at any time in case of fire. A gantry floor covered by a hand traveling crane extends over all the transformer rooms, also partly over the turbine pits, so that the turbine wheels, as well as the transformers, can be placed or raised out of their positions by a single traveler and delivered to the gantry floor. The gantry floor is on a level with the roadway leading to the power house. The main water gates are double-leaf sliding gates, operated by rack and pinion hoist, motor-driven. Each turbine chamber is supplied with an auxiliary filling valve.

The power house building will be steel construction, brick filled. The dynamo room floor and the switchboard floor, however, will be re-enforced concrete. The dam extending from the power house to the east bank will be of cyclopean concrete work. There will be a water stop wall on the west side of the building to the west bank 85 ft. high from low water mark in the tail-race to the west bank. At the present time the power house is well under way, the excavation having been completed and the concrete work being well along. It is expected that this plant will be in operation on or about Dec. 1, 1907.

The Spokane River Diverted Around Power House Site.

The current from this plant will furnish light, heat and power for the city of Spokane, the Inland Empire Co. having a broad franchise in the city. It will also be used to develop the country through which the lines of the Inland Empire System operate, furnishing power as far south as Moscow and possibly farther. The Inland Empire Railway System owns other power site which will be developed when the power from this development shall have been used. The work of construction is in direct charge of F. M. Sylvester, local manager for Messrs. Sanderson & Porter.



General View of the Power Site Being Developed by the Inland Empire System.

The New Sand Filters, of Paris, France, will serve an outlying district with a population of 160,000, with 7,700,000 gal. of water daily. Until now the district served has been supplied with unfiltered Seine water. Before the water passes on to the beds it is clarified by simple subsidence and straining in a set of four small tanks, each subdivided into four parts. Here the water is cleared of its grosser impurities by passing through coarse gravel. It then flows on to the prefilters, which are of large-grained sand, through which it travels about seven times as fast as through the final beds. The speed of filtration slows down from the first to the last filters, while the beds traversed gradually increase in thickness. Between the various filters the water falls in cascades for the sake of the aeration. A siphon regulator on the Didelon system is here employed for the first time. It is stated by M. Le Couppey de La Forest, from whose article in "La Nature" these notes have been taken, that since filtered water has been supplied to this district, in lieu of raw river water, the mortality from typhoid fever has sunk in a year from 180 per 100,000 to 43 per 100,000. This is below the totals for Paris during the same period, where the mortality was at the rate of 67 per 100,000.

The Checking of Structural Steel Deliveries for Mill Buildings.

By F. L. Smith, Chief Draftsman, Joseph H. Wallace & Co., Consulting Industrial Engineers, New York.

Probably one of the most difficult matters to keep track of on a job of any magnitude is the structural steel work, that is, from the point of view of the resident engineer.

Contracts are usually entered into with the sturctural steel companies to furnish material in accordance with certain drawings and specifications. It is more often omitted than included in these contracts, to fix a definite schedule of shipment, for reasons too numerous to mention and which at the time of drawing the contract are valid. It is also always the case in mill work that the steel contractor is required to furnish the work within a period which is almost beyond the capabilities of his plant or at least beyond his reach for obtaining the material.

The first duty that devolves upon the contractor is to list his material and have it ordered from the rolling mills. He, therefore, schedules his material at the earliest opportunity and orders it from the mill. Those who are familiar with the rolling schedules of the mills will readily appreciate that perhaps he gets the material in the order for which he contracts for it, but more often he does not. Consequently, when the material finally arrives it comes in all sorts of shapes and entirely out of the order in which it was arranged for, and in order that the plant of the contractor may not become glutted, for this job may be only one of many, he works it through the plant to get it out of the way, and then his storage facilities being limited, it becomes necessary to ship it. So when it arrives at the site of the proposed plant, there may be ten pieces for one building and a hundred for another, and so on, no systematic shipping of material complete for any one building being possible to adhere to, for the reasons above mentioned.

This is where the enormity of the task confronting the resident engineer presents itself. Assuming that the contract provides for 85 per cent. payment on arrival of the material, the engineer must have some means whereby he can check the material to his satisfaction, to be sure that the material that is being shipped is really part of his work, and also to determine the amount of money named in the contract for 85 per cent. payments. It is quite impossible to weigh or even think of weighing the material on arrival at site, and, as frequently is the case, the railroad weights are not procurable.

Covering a period of some years of handling structural steel work for mill buildings and trying out various schemes for checking and deciding upon payments to be made the steel contractor, I believe the most satisfactory arrangement is, first, for the contractor to ship from his shop drawings, after approval by the consulting engineer. These drawings, with the marks of all pieces and weights, which have been figured by the consulting engineer at his home office or furnished by the contractor, can be checked thoroughly enough at the home office to make certain that all the material has been detailed.

When the shipping commences, it is advisable to request, and to enforce the request, that the contractor shall submit in duplicate shipping bills, a bill for each building with the number of pieces of each mark and the length of the pieces plainly stated. These bills are submitted to the home office, which office, in turn, after checking off the pieces covered on the various bills on the contractor's erection plans or detailed drawings, whichever are most convenient, sends these bills to the resident engineer in charge of this work in the field.

On the arrival of the material the engineer has simply to check his marks and report back to his office either the correctness or the error in the particular bill or bills of materials sent him under a stated date and covered on shipment of certain car numbers.

In the interim between the sending of the bills and the return by the field engineer, the home office has had time to make up the weights from the detailed drawings previously figured, and is then in a position to determine the amount of money due the contractor under the terms of the contract.

In the handling of some 7,000 to 8,000 tons of material, this arrangement has been found to work absolutely without failure, preventing all controversy between the contractor and the engineer acting for the owner or the owner in his own behalf, as to the amount of money due the contractor at any specified time.

Several other arrangements were tried before this one was finally settled upon, one of which was to list the material shown on the contractor's various detailed drawings on separate shipping lists, printed on light bond paper for blueprinting purposes, sub-dividing this material under trusses, columns, beams, channels, etc., the sheets being ruled in vertical columns under the following headings: Mark of Piece, Number, Description, Length, Date of Shipment, Car Nos., Date of Arrival, and Condition.

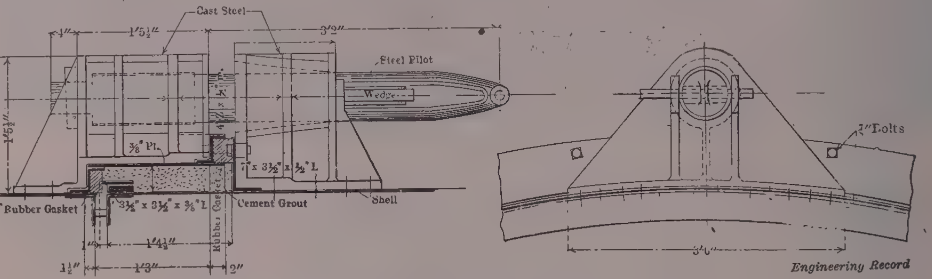
Even though several columns were allowed for the dates of shipment, and numbers of pieces shipped, dates of arrival, condition, etc., it was found that where there were a number of pieces of one mark that in no one instance were all the pieces of one mark shipped at one time. This of course lead to a multiplicity of entries on the original sheets at the home office from which blueprint had to be made each time a shipment was made and forwarded to the field engineer. It was expensive to blueprint, the filing was also an additional expense, as well as the necessary time spent in checking by the field engineer, and the outcome was a hopeless tangle that for future reference was useless.

Another method was tried, that of allowing the contractor to furnish bills of material as each shipment was made, regardless of assembling the pieces under the heading of the building in which they were to be used. This was unsatisfactory because of the amount of work entailed in checking up from the sheets, and also because it was difficult to decide on the exact amount of money due the contractor at any stated period from the home office; because the sheets were being held by the engineer for checking. Particularly was this true where the material was not distinctly marked.

In all this experience the majority of the trouble was encountered through lack of proper marks on the part of the contractor on the various pieces comprising the contract. The shop superintendent of a bridge shop seems to feel that the responsibility of marking the pieces correctly is something that it matters little whether he assumes or not, just so long as the fabrication is finished and his monthly weekly tonnage is accomplished. From this source alone untold trouble arises for both the field engineer in checking the material and the contractor in collecting his monthly payments, for when the marks become obliterated, or mixed, or incorrectly given, as is too often the case, I regret to state, there is immediately the question as to the correct mark of the piece or pieces, which in many instances, and in fact most instances, is seldom settled until the completion of the shipment and final erection of the building or buildings.

I believe that by the first method outlined and by the careful inspection of the work by the contractor in his shops, especially during the final shop coat paint to see that the erection marks are not obliterated, considerable trouble and expense would be saved to both the contractor and the engineer in charge of the work in the field.

Inspection of structural steel work comprised in mill building use is too often omitted. It is just as important a matter from the owner's standpoint to have the work inspected as it is a benefit to the contractor; particularly is this true when the work is in a hurry and a large amount of money is invested in the total cost of a plant. If through the lack of proper inspection on the part of the contractor in his shops, or carelessness on the part of his superintendent or foreman, material is shipped which, when ready to be erected, is found to be quite different from the detailed drawings, the work may be delayed days and the completion of the plant deferred weeks through having to wait for new members to replace those in error. This is particularly true where special sizes of material have been specified.



Detail of Tube Splices, Detroit River Tunnel.

My experience is that such occurrences are minimized by the inspection on the part of the engineer of the work while in the shops of the contractor, even though the contract with the contractor provides for the erection of the work. It is not usually the custom to enter into a contract or even intimate a disposition to require the contractor to furnish damages for delays in construction due to shop inaccuracies, on the basis that mistakes are bound to happen in the best of regulated families.

In the event of the contract providing for furnishing the material simply f.o.b cars site of the proposed plant, it is hardly necessary to say, inspection is absolutely necessary.

During the process of shop inspection it is much easier to see and correct defects and the engineer has more time for this purpose than when checking the material at its arrival at the site, at which time little or no attempt is ever made to look for defects or inaccuracies in the various members, and even though they are discovered in advance of the time set for the erection of the pieces, there is always more or less delay and squabbling before amicable adjustment of the squabble is reached and the material made satisfactory to the engineer.

Asphaltoilene, an asphalt oil, has been used of late on macadam roads in and about Lexington, Ky., Detroit, Mich., Evanston, Ill., Norwood, Ohio, and other cities. Reports show that the oil apparently gives a dustless, waterproof road, and that one application per year is sufficient to keep the road in good condition. Asphaltoilene is made and applied by the Good Roads Improvement Co., of Cincinnati, Ohio.

The Detroit River Tunnel of the New York Central Lines.

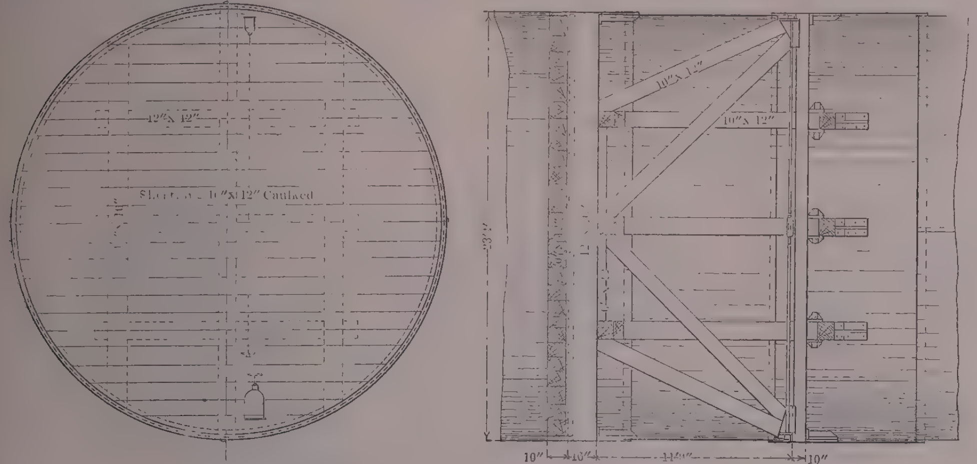
The main lines of the Michigan Central R. R. have hitherto been connected across the Detroit River only by means of a car ferry between the cities of Detroit, Mich., and Windsor, Canada. The improvements now being made in Detroit provide for the rectification of the existing lines in Detroit commencing near the curve at the entrance of the Union Depot and extending through a tunnel under the Detroit River nearly at right angles to it and thence to the proposed passenger station and new freight yards in Windsor, where it connects with the existing main line.

All of these tracks between the west Detroit yard and the Windsor yard, including the latter, will be comprised within an electric zone about 23,000 ft. long and will have a double track entering Detroit open cut 1,540 ft. long with a grade of 0.44 and 2.0 per cent. and continuing through 2,129 ft. of land tunnel at a grade of 2.0 per cent. to the Detroit shaft, thence through the subaqueous tunnel 2,622.5 ft. long at a depth of 41.75 ft. from the top of the roof to the surface of the river, then past the Windsor shaft, through the east approach tunnel 3,192 ft. long at an upgrade of 1.5 per cent. and through an open cut 3,300 ft. long at the same grade. Most of the subaqueous tunnel is on a horizontal tangent.

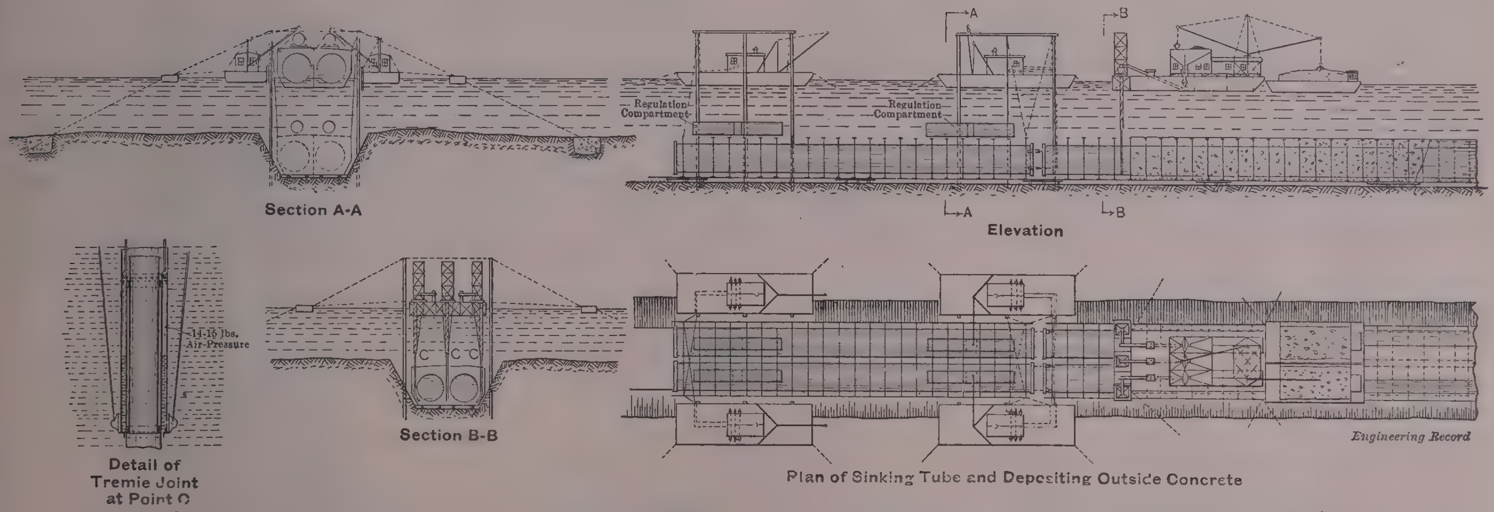
Four alternate general plans for the subaqueous tunnel were prepared as described in The Engineering Record of Feb. 17, 1906, by Mr. W. J. Wilgus, Mr. H. A. Carson and Mr. W. S. Kinnear, the advisory board of engineers, and bids for the work were invited in accordance with them and with modifications proposed by the bidders. One of the original plans contemplated the construction of the river tunnel with a dredged trench filled with a large mass of concrete extending about to the present river bottom and containing twin tubes of reinforced concrete 18 ft. in interior diameter. It was proposed to deposit under water, a footing of concrete in the bottom of the trench, place saddles on it, sink forms on them and then fill in the concrete surrounding the forms and finally remove the forms and build the reinforced concrete lining inside by means of a slight air pressure. A second plan differed from the first, principally in the use of annular I-beams for reinforcing the concrete lining; a third plan contemplated the construction of the tubes on dry land and sinking them to position on the concrete foundations. A fourth plan was the excavation of the tunnel by the ordinary shield method operated under a temporary blanket of clay deposited in the bottom of the river.

A study of the preliminary plans and an investigation of the site and conditions by the successful bidder resulted in the preparation and the submission by him of a modification of the first plan mentioned, which was changed principally in making and sinking the concrete form for the tunnel tubes and in the method of depositing and retaining the concrete surrounding them, also in eliminating the use of compressed air altogether. In accordance with these features, the final contract plans for the tunnel were prepared by the engineering department of the Detroit River Tunnel Co., a subsidiary company of the New York Central Lines, and the work was awarded to Butler Brothers Hoff Co., New York, on their modified plans.

The open cut work is of a simple nature and consists of an excavation of a maximum depth of about 30 ft. with concrete retaining walls with battered faces and offset backs increasing to a maximum thickness of about 10 ft. at the base. The approach tunnels are twin concrete structures with a common vertical center wall 4 ft. thick above the conduit chambers. They have full centered roof arches 2 ft. thick with inside radius of 8 ft. 3 in. and a clear height of 18 ft. above the rail. The side walls at special places are battered on the outside to a thickness of 5 ft., otherwise are battered to thickness of 2 ft. 9 in., and are integral with the invert concrete 2½ ft. thick below the center drain. All of the concrete is inclosed in a layer of waterproofing protected by a 4-in. concrete outside wall or a single course of hard burned brick. The Detroit shaft is 74 ft. 9 in. deep to the bottom of the concrete and has an oval cross section with long and short diameters of about 59 ft. and about 20 ft., respectively, outside dimensions. It contains two 13½x16½-ft. vertical oval openings, a central stair well and two conduit wells. The base of the rail is 56 ft. 9 in. below the top of the concrete and under it there are two sumps of 21,000 gal. capacity with a pump and motor chamber between them. The Windsor shaft is similar except that the depth is increased to 93 ft. to bottom of concrete.



Contents of Full Pressure Bulkhead.



Section A-A

Elevation

Detail of Tremie Joint at Point O

Section B-B

Plan of Sinking Tube and Depositing Outside Concrete

Diagrams of Methods of Construction Suggested for the Detroit River Tunnel, But Since Changed.

The detail of the tremie joint is given as a matter of interest, although it has been decided not to use it.

The subaqueous tunnel has a cross section slightly modified from that of the original plans and is symmetrical about the center vertical line. The two tubes 20 ft. in interior diameter are 26 ft. 4 in. apart on centers and 20 in. thick, leaving a clearance of 3 ft. between them on the center line. They are inclosed in a mass of concrete 55 ft. 8 in. wide and 30 ft. 10 in. deep over all. The tubes are made with an exterior shell of ⅜-in. steel plates lined with concrete 20 in. thick, reinforced by 1-in. longitudinal horizontal rods 18 in. apart on centers which are located about 6 in. beyond the interior surface of the concrete. The lining is made with 1:2:4 concrete and exterior concrete is proportioned 1:3:6. On each side of each tunnel there are staggered splicing chambers 400 ft. apart, ladders 50 ft. apart and a single line of hand holes 40 ft. apart. Ducts for power, lighting, telegraph and signal conduits are contained in benches on each side of the track which at the splicing chambers have their vertical front walls reinforced with four tiers of horizontal rails. Near the center of the river there is provided a 4x12-ft. sump, with four 5-ft. transverse tunnels about 41 ft. long and 4 ft. in diameter under the main tubes and communicating by a vertical shaft with pump chambers 6½ ft. in diameter and 19 ft. long at the height of the center line of the tunnel.

The location of the tunnel was thoroughly explored by four test pits and by 214 test holes, the latter 100 ft. apart, approximately located in two parallel lines from 50 to 100 ft. from the center line of the tunnel, and extending from end to end of the open cut. The borings were made with a churn drill working inside a 2½-in. casing through which water was forced on the center line of a 1 15/16-in. hollow drill bar. The borings indicated that most of the material encountered by the subaqueous tunnel was soft blue clay with rock at a distance of 10 to 20 ft. below the invert. The test pits were dug near the river shafts and between them and the portals of the approach tunnels.

Current observations were recorded showing minimum and maximum velocities of 1.17 ft. and 2.29 ft. per second at the bottom, and an average elevation of water surface of 575.3 ft.

The construction adopted has riveted steel tubes 23 ft. 4 in. in diameter built on shore in sections 262.5 ft. long launched floated to position and sunk with the aid of air cylinders to position on a steel grillage with alignment beams laid in a dredged trench with a maximum bottom width of 48 ft., depth of 32 ft. and assumed side slopes of ½:1 one such grillage coming at each joint. The tubes are connected by sleeve joints with rubber gaskets made by divers and then grouted. The tubes are surrounded by a monolithic mass of concrete deposited under water through steel tremies in an outside form with vertical walls between which and the sides of the trench, the space is backfilled. The interiors of the tubes are lined with concrete 20 in. thick.

The upper part of the trench is excavated by a dipper dredge and the lower part by a clamshell dredge provided with a specially designed clamshell bucket. The bottom is approximately leveled and the steel grillages mentioned above sunk into accurate position to receive the steel tubes.

The steel tubes are made with ⅜-in. plates with calked lapped joints having double rows of ¾-in. rivets. The exterior of each tube is reinforced with vertical transverse diaphragms 12 ft. apart made with ⅜-in. plates reinforced by pairs of 3½x3½-in. flange angles on the outer edges. The shape of the plate conforms with the cross section of the concrete jacket, the lower edge being horizontal to serve as a cradle supporting the tubes on the steel grillage in the trench. The inner edge is vertical, forming a flanged butt joint with a slight clearance from the twin tube alongside. The vertical and inclined outer edges of the diaphragms are sheathed with horizontal longitudinal planks which when the tubes are sunk, form the walls of the concrete form. Intermediate between the diaphragms are inside 3x3-in. flange angles with connections for twelve 1-in. adjustable radial rods connected to a center ring to provide interior bracing and serve as tension members like the spokes of a bicycle wheel. Similar bracing is provided at each end of each tube, to prevent deformation in handling. Before launching, each end of each tube is temporarily closed with a bulkhead having a transverse wall of seven courses of 10x12-in. timber planed and calked. These timbers take bearing against the 3½x3½-in. inner flange angle and have three vertical lugs riveted inside the tube about 13 ft. beyond the bulkhead. The forward end of each tube is provided with a sleeve 17 in. long which projects beyond the end of the tube and about 3 in. beyond it radially forming a hub to fit over the adjacent end of the previous section already sunk. The sleeve is provided with outside flanges at the inner and outer ends, respectively, and corresponding flanges on the entering end of the next section of the tube, match them and engage the solid rubber gaskets. These close both ends of the hub space which is additionally sealed by a filling of cement grout.

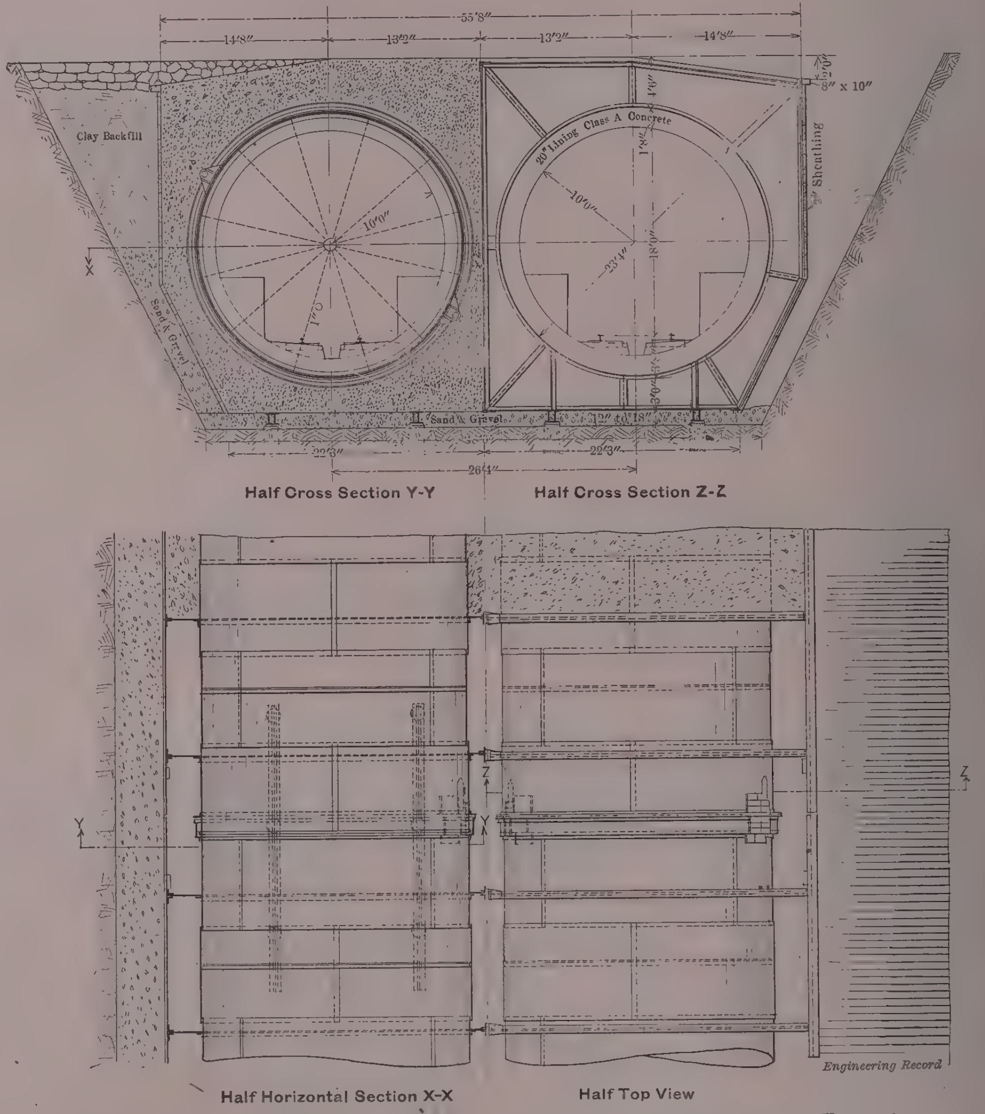
A pair of twin tubes 2,622.5 ft. long together weighing about 550 tons are launched transversely and floated to position between rows of guide piles about 30 ft. each side of the center line of the tunnel. Each tube is equipped with two horizontal steel cylinders about 10 ft. in diameter and 60 ft. long temporarily secured with adjustable chains to cradles in the diaphragms as indicated in the general elevation.

Inlet valves in the bottoms and outlet valves in the upper part of the bulkheads are opened, the water enters through the former and the air escapes through the latter causing the tubes to sink slowly until the outlet valves are submerged. The latter are located so as to retain a certain quantity of air above them which gradually escapes through vent valves operated from the attendant scows. Finally enough additional water is admitted to sink the tubes below the surface until the air cylinders on top commence to be submerged and maintain the tubes in the horizontal position, preventing them from sinking farther until their buoyancy is overcome. The air cylinders are ballasted by admitting water ballast or expelling it with compressed air until the combined weight of the tubes and cylinders produces a tension of only about 10,000 lb. on the lines attached to each end. They are thus maintained in even balance and gradually lowered to the bottom under perfect control without danger of severe stresses or distortion.

To facilitate the passing of the sleeve of each tube over the end of the adjoining tube, both of them are provided with pairs of cast steel sockets bolted to the exterior of the shell close to the joint. The sockets are bored for pilot pins 6 in. in diameter and 5 ft. long parallel to the axis of the tubes which are set to project about 40 in. beyond the end of the sleeve. The tubes are sunk with the sleeves at the rear end, a steel cable is led from a winch on the scow around a sheave attached to the last tube sunk and thence through the conical hole in the outside lock casting and secured to the tapered end of the corresponding pilot in the tube about to be sunk. Lines or preventing tackles are attached to the opposite end of the floating tube and as it gradually descends to the bottom of the trench, the winch lines are operated drawing the rear end of the tubes to position and finally leading the conical ends of the four pilot pins for the two tubes into the conical openings of the flange castings and thus centering the tubes and enabling them to be drawn close together forming a telescopic joint between the sleeve and the end of the adjoining tube.

As the sleeve and the engaging end have previously been carefully assembled and fitted together before launching, the alignment is assured, and when the tube is in position the joint is locked by wedges driven by divers through slots in the projecting ends of the pilot pins. The pocket enclosed between the rubber gaskets of the sleeve is pumped out and the space filled with pure cement grout delivered to it by a force pump through a flexible pipe to the scow, a second pipe providing for the escape of the air and showing when the space is filled by the discharge of grout through it. The forward end of the tube is adjusted by its lines and the operations are repeated for successive sections of the tube. Alignment is made by vertical steel frames bolted to the tubes and extending above the surface of the water.

As soon as the joints and alignment are completed, water is admitted to the air cylinders until the chains attaching them to the tubes are slackened and the weight of the latter is gradually transferred to the foundations. When the chains are released, the water is expelled from the air cylinders by pneumatic pressure and the cylinders rise to the surface and are used again for sinking the next pair of tubes. The tubes are arranged to be sunk simultaneously in pairs with a longitudinal adjustment of about 3 in. between them to allow for possible difficulties in making the two joints if the ends should not be found in exactly the same plane.



Half Cross Section Y-Y — Half Cross Section Z-Z

Half Horizontal Section X-X — Half Top View

Approved Design of Subaqueous Section of Detroit River Tunnel.

In the original plans it was proposed to deposit the outside concrete in the open trench, but in order to prevent the possibility of its flowing too far laterally and to largely reduce the amount required, the system of form walls and transverse diaphragms already described was designed by the contractors and forms separate pockets each with a capacity of 350 cu. yd., which are filled from the scow above through three steel tremie tubes mounted in vertical guide frames. If necessary, the concrete can be deposited through moveable flat roof shields enclosing the tops of the concrete pockets and easily moved from one to another on the top of the side wall so as to protect the fresh concrete from the wash of the river.

The work is expedited by building the concrete lining inside the tubes simultaneously with the sinking of the tubes and the outside concreting, keeping at a fixed distance of about two tube lengths behind the latter work. For this purpose, heavy water-tight bulkheads are provided in alternate tube sections and receive the full hydrostatic pressure of the open end of the tube when the water inside the steel tubes has been pumped out.

The underlying principle of the construction and design is as follows:

The steel shell serves first as a form or mould for confining the outside concrete deposited through the water, and later forms a perfect waterproofing for the completed tunnel.

The outside concrete, which is deposited in water, is of sufficient dimensions and strength to resist the hydrostatic pressure, when the water inside the steel tubes is pumped out, in order to enable workmen to go inside of same and construct the tunnel proper without the employment of compressed air.

This outside concrete deposited in pockets of 350 cu. yd. each, as described, will fill up all depressions and irregularities in the bottom of the tunnel trench and make, so to speak, its own bed. In this connection it should be noted that when each pocket is filled, the pressure per square foot on the bottom of the trench is greater than it is for the completed tunnel loaded with locomotives. This is a great advantage as it will eliminate any tendency of settlement after the tunnel is completed and taken into use. In other words, if the bottom has a tendency to yield or settle it will do so while the outer concrete is being deposited rather than after the tunnel is completed.

The tunnel proper, which is built inside of the steel shell and outer concrete casing is built of sufficient strength to resist independently all loads, whether hydrostatic, static or live loads, that may come upon it. It can be built in long sections at a time and under a strict and reliable inspection as to quality of materials and workmanship.

The interior radial rods employed to keep the steel shell in shape until the outside concrete is set, are, of course, removed as the work progresses on the tunnel inside.

The cross sectional area of the 20-in. concrete lining is 113.5 sq. ft. The buoyancy of the tube at 62½ lb. per cubic foot is computed to be 26,725 lb. per linear foot; subtracting from this the weight of the lining at 140 lb. per cubic foot, 15,188 lb., gives a reaction of 10,837 lb. per linear foot for the outside concrete. Assuming that this reaction is distributed evenly over the diameter of the tube it is computed that, the sum of all moments being equal to zero, the maximum and minimum stresses per square inch are 260 lb. and 58 lb. at the top of the lining, 288 lb. and 85 lb. at the center and 293 lb. and 91 lb. at the bottom, thus showing that the stresses are kept well within reasonable limits.

The tunnel is being built under the supervision of Mr. W. S. Kinnear, chief engineer, who is also a member of the board of engineers mentioned at the beginning of this article.

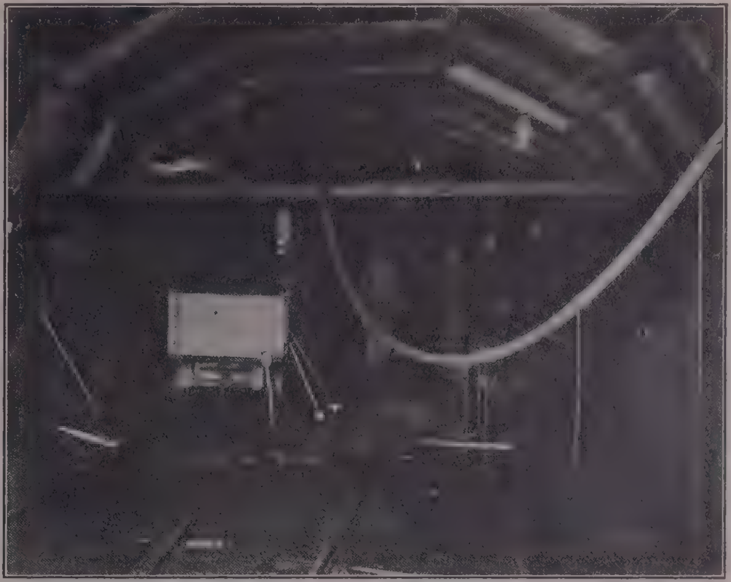
The contractors for the tunnel are the Butler Brothers Hoff Co., of 1120 Broadway, New York City, the amended design submitted by them with their proposal having been prepared by the vice-president of the firm, Mr. Olaf Hoff, M. Am. Soc. C. E.

THE FIGURE OF THE EARTH has recently been investigated by the U. S. Coast & Geodetic Survey by methods radically different in some respects from any previously used. According to Mr. John F. Hayford, the work was based on 507 sets of astronomical determinations at many different stations and on continuous triangulation from the Atlantic to the Pacific and from the Great Lakes to the Gulf of Mexico. The investigation showed that, for the United States and adjacent areas, the assumption that the material of the earth is sufficiently rigid to maintain the continent in position vertically is untrue. On the contrary, the assumption that the earth is in the condition termed isostasy is closely correct. In other words, the United States is not maintained in its position above sea level by the rigidity of the earth, but is floated, in the main, because it is composed of material of deficient density, extending probably to a depth of about 70 miles. The flattening of the earth, according to this investigation, is between the values assigned by Clarke and Bessel, while both the equatorial and polar dimensions are found to be larger than stated by the authorities mentioned.

The Bronx Storm Relief Sewer Tunnel.

To provide for the greatly increased sewage from a large area in the Borough of Bronx, New York, where very extensive real estate improvements are being rapidly made and the volume of storm water and sewage to be disposed of is increasing continually, a relief sewer is now being constructd from Webster Ave. near Wendover Ave. in a westerly direction to the Harlem River about 230 ft. north of High Bridge. It has a total length of 6,900 ft., 5,700 ft. of which are constructed in tunnel and the remainder in open cut. The alignment is mostly tangent with horizontal curves at Teller Ave. and at Macombs Road, the vertical alignment is made up of two long tangents with a vertical curve near Jerome Ave. and with a maximum grade of 0.23 ft. per hundred. It is proportioned for a maximum discharge of 1,350 cu. ft. per second at a velocity of 9 ft. per second, and is built with two standard cross-sections one for the tunnel and the other for the open cut construction.

Old Sewer across Cut.


Timbering in Bad Rock.

It is provided with two permanent shafts and has special construction at the upper end where there is a gate chamber; and at the outfall. The surface of the ground over the tunnel presents four principal summits about 70, 105, 120 and 140 ft. above the tunnel roof respectively from the east to the west end. Under the first summit, the tunnel passes for about 1,000 ft. to the first horizontal curve under Claremont Park, the remainder of the alignment crosses the city blocks nearly at right angles to the direction of the avenues, thus enabling the shafts and portals to be located on or near the streets and provides for convenient delivery of materials and removal of spoil, all of the former and part of the latter being accomplished by trucks and wagons. Some of the spoil is, however, delivered to dump cars on tracks running to the edge of fills where low ground is being built up with the excavated material.

At the intersection of Wendover and Webster Aves. where the tunnel commences the sewage is delivered to it through a pair of new horseshoe shape twin sewers 8½ ft. wide and about 8½ ft. high adjacent and parallel to a similar old brick sewer 7½ ft. wide and 7 ft. 8 in. high, which up to the present time has carried the storm water and sewage through Webster Ave., the flow of which will be diverted to the tunnel when the latter is completed. As it is possible that it may be desirable to empty the tunnel sewer for purposes of inspection, repairs, extensions or other construction, advantage has been taken of the existence of the old sewer to arrange for its use as a by-pass.

To this end, the twin intakes of the tunnel sewer are connected to the tunnel with a gate chamber of irregular dimensions about 45 ft. long, 30 ft. wide and 20 ft. high over all with the roof 5 ft. and the invert 25 ft. below street level. Channels are provided in the floor of this gate chamber connecting the twin sewers and the old sewer across it with the entrance to the tunnel. Gates are also provided to control the flow in each of these conduits and the connection from the gate chamber to the outfall of the old Webster Ave. sewer. Ordinarily, the latter gate is closed and all the rest are left open allowing all the flow to pass through the gate chamber into the tunnel sewer. The flow may, however, be diverted from the tunned by opening the gate connecting the chamber with the Webster Ave. outfall and closing the other gates. As the headroom was very much limited, wooden gates operated by beveled gears commanded by a horizontal shaft and sprocket chains were provided and controlled from the second floor of the gate chamber.

The gate chamber is made entirely of reinforced concrete with a heavy floor slab serving as a foundation and distributing the pressure on the sand and earth over its entire area. The roof and walls are reinforced with steel bars from ¾ in to 1½ in. in diameter, most of them being spaced 6 in. apart longitudinally and transversely except in the walls where only vertical bars are used.

Most of the tunnel excavation is in rock, of which a typical cross-section is shown. The lining is of 1:3:6 concrete made with stone broken to pass a ¾-in. mesh and be retained by a ⅛-in. mesh. The interior surface has a 1-in. mortar finish and the cross sectional area is 146 sq. ft. The area of the maximum allowed rock excavation is 215 sq. ft. and allows a margin of 6 in. beyond the minimum limit, spaces occurring in this area being carefully packed with stone. Drain pipes 3 in. in diameter are placed in the roof arch at the springing line, and 4x8-in. weepers are built in the side walls where required just above the invert.

The invert concrete is laid on a 3-in. bed of broken stone which reaches to a center subdrain of 12-in. vitrified pipe with open joints laid in broken stone. The west end of the tunnel is connected with the outfall by about 250 ft. of concrete sewer built in open trench and having a rectangular cross-section as shown at station 5 + 10. The 1:2:4 concrete is reinforced with

1¼-in. horizontal transverse bars 6 in. apart on centers in the roof where alternate ones are bent up at the ends as indicated by the dotted lines. The side walls and the invert are both reinforced with 1-in. bars 6 in. apart.

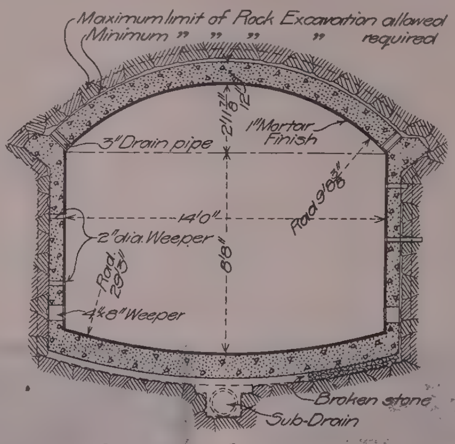
The open cut portion between the two tunnels has a cross-section similar to that above described, differing chiefly in the spacing of the invert reinforcement bars which are here 12 in. apart. Where the rectangular open cut section changes to the arch tunnel section, the thickness of the roof also changes from about 26 in. to 12 in., thus producing a rectangular offset in the concrete which is additionally reinforced by horizontal longitudinal 1-in. bars 8 ft. long in the roof of the arch section which project 2 ft. into the flat section. Similar bars 12 in. apart vertically are set in the side walls and project alternately 2 ft. and 4 ft. from the rectangular into the arched section.

At the outfall, the sewer passes under the tracks of the New York Central & Hudson River R. R., and is supported on piles driven in the soft mud in transverse rows about 3 ft. apart. Horizontal transverse planks are bolted to both sides of the piles and act as beams to support a floor of two crossed layers of 2-in. planks fitted around the piles. The invert concrete 4 ft. thick is reinforced near the lower surface with one longitudinal and one transverse ½-in. bar between each row of piles, and with ½-in. longitudinal and transverse bars 24 in. apart just above the pile tops.

On the monolithic platform, thus provided, the sewer is built with a rectangular cross section about 28½ ft. wide and 10 ft. high over all. This contains two twin rectangular openings 12 ft. wide and 7 ft. 4 in. high with concave inverts, horizontal roofs and vertical walls separated by a partition wall 2½ ft. thick. This construction was adopted to conform with the limited clearance under the railroad tracks. At the outlet a vertical face wall 43 ft. long transverse to the tunnel axis, is continued about 2 ft. above the top of the roof, is finished with concrete coping and has short side walls, clusters of fender piles, and double rows of wing piles at both ends to protect the projection beyond the shore line.

Where the twin section joins the regular section, the side walls converge with tangents about 45 ft. long, eased off with curves at both ends. The head of the partition wall is finished with a vertical cut-water of granite 2 ft. 6 in. thick dressed to a sharp point at the up-stream end.

Where the railroad tracks cross the sewer at the beginning of the twin section the thickness of the vertical side walls is increased to 3½ ft. at the top and 5 ft. at the bottom, and the roof is reinforced by six pairs of 15-in., 100-lb. transverse steel I-beams longitudinal with the tracks and 3½ ft. apart on centers of pairs. This section of the sewer, about 160 ft. long, is not supported on piles and the invert is reinforced close to the upper surface of the concrete by 1-in. horizontal transverse bars 4 in. apart on centers.



Section in Good Rock.

The open cut sewer crosses at right angles under the Macombs Road brick sewer 3 ft. in diameter which is supported on a rubble masonry wall in which an arch of about 16-ft. span and 4-ft. rise is sprung to clear the sewer.

The open cut sewer also crosses at oblique angles under the 6½-ft. brick sewer in Inwood Ave. Here the regular cross section is maintained, but the side walls are made heavier by offsetting the exterior to a maximum thickness of 4 ft. and the thickness of the roof is decreased at the center of the Inwood Ave. sewer invert to 15 in., and is reinforced by transverse 12-in., 55-lb. I-beams 12 in. apart on centers. The I-beams are connected by three lines of tie rods, and wire netting of No. 12 gauge covers the lower flanges of the beams to receive the 1-in. mortar finish. Adjacent to the beams, the roof concrete is reinforced by a lower tier of 1½-in. transverse bars 6 in. apart and longitudinal ½-in. bars 24 in. apart and by an upper tier of ½-in. longitudinal bars 12 in. apart.

The tunnel is accessible through two permanent concrete shafts, one of them in the portion built in open cut about midway between the two ends of the sewer and the other about 1,300 ft. from the upper end. The latter has a total depth of about 50 ft. from the surface of the ground to the tunnel roof or about 85 ft. from the tunnel invert to the top of the house which surmounts it. Both shaft houses have walls of reinforced concrete and the shafts have a rectangular cross-section with inside dimensions of 10 x 14 ft. at the top, one of the side walls being battered to give it a length of about 16 ft. at the bottom in the direction transverse to the tunnel axis. Zigzag iron stairways descend from the surface of the ground to a platform above the tunnel roof where it is proposed to install instruments for recording the velocity of flow at different parts of the cross-section.

The open cut sections of the sewer are built in trenches having a maximum depth of 50 ft., and an average depth of 30 ft. excavated through earth and into the rock. The upper part is sheathed with single lengths of 2-in. plank reinforced in some instances by a second thickness alongside when the pressure was found too great for the first set. Excavation was made with hand digging, drilling and blasting, and materials were hoisted from the trench by steel buckets operated by mast and boom derricks and dumped into wagons. Little difficulty was experienced with water which was easily removed by steam pumps. All open cut excavation has been completed except at the crossing of the railroad tracks near the outfall and at the Webster Ave. gate chamber.

At the intersection of Macombs Road, the sewer passes under a 3-ft. brick sewer with concrete invert which was supported across the 20-ft. trench on transverse sills at four approximately equidistant points. Near the sides of the trench, the sills were carried directly by vertical posts, but in the center of the trench such supports would have interfered with the sewer construction, therefore the sills were carried by pairs of braces inclined like rafters, fastened together at the crown and bolted at the lower end to the feet of the vertical posts.

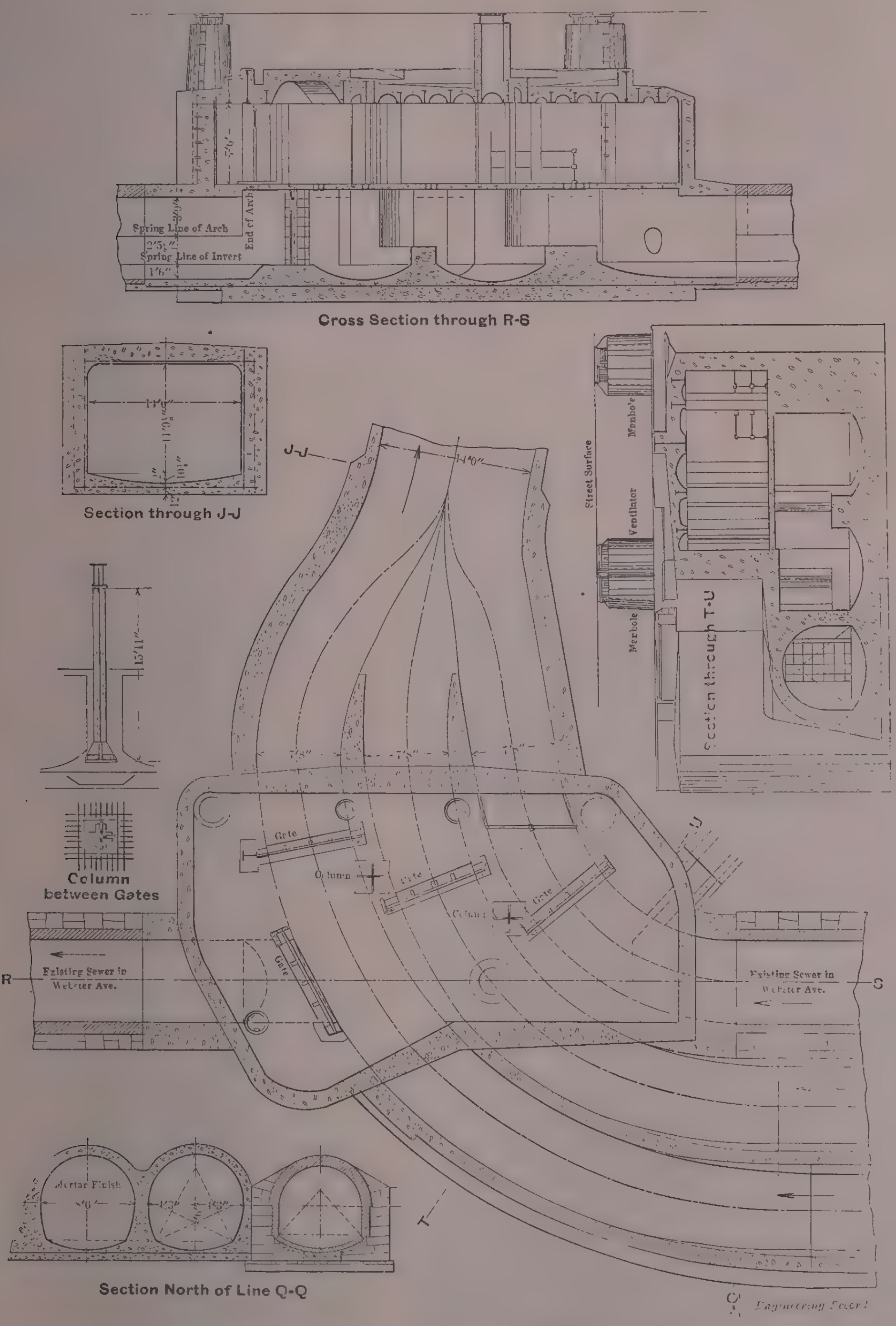
The Inwood avenue sewer is supported across the excavation 20 ft. wide, on a pair of heavy wooden sills parallel with its axis and serving as girders spanning the trench and supported by vertical trestle bents at both ends and by intermediate bents removable when necessary to provide clearance for the concrete construction. The sills were set just outside the old footing on the bottom of the incompleted trench as soon as the excavation was carried to that depth. Narrow transverse planks were driven like poling boards

Crown Bar Timbering in Heading.

Old Sewer Supported on Beams.

across the tops of the sills bearing against the under side of the footing and receiving its weight as the bottom of the trench was gradually excavated to a greater depth, the sills being maintained in position by blocking and wedging which was finally replaced by the vertical bents when the trench was completed.

At Cromwell Ave., the trench was about 40 ft. deep and the vertical sheathing boards were braced by one set of transverse struts near the top of the bank which were spaced about 6 ft. apart with their ends knee-braced to the rangers at the centers of the panels. East of the railroad tracks near the outfall, the excavation was in very soft ground and the trench was sheeted with a double row of 2-in. square-edge sheet piles driven by hand and braced with three tiers of 12x12-in. transverse struts.


Cross Section through R-S

Section through J-J

Column between Gates

Section through T-U

Section North of Line Q-Q

Gate Chamber and Connections at Webster Avenue.

Surveys were made carrying the alignment of the sewer in an air line over the tops of all obstructions, the stations being selected so as to give clear sites on tangents. In some cases the instruments were set on the house tops and alignment and grade were established with points marked by brass tacks driven in heavy stakes less than 50 ft. apart. Distances were measured by a 50-ft. steel tape with spring tension adjustment and were corrected for temperature and slope. Most of the points in the tunnel are preserved by horse-shoe nails driven in the arched timbers and having their heads perforated to receive the plumb bob line.

At the Morris Ave. shaft the excavation is through decomposed seamy Stockbridge dolomite so soft that it can be cut with picks without blasting. The stratification is regular with a dip of about 50 deg. At Webster Ave., the rock is a good quality of sound Fordham gneiss. At the Inwood shaft, the east heading is through Stockbridge dolomite with horizontal and folded stratification very troublesome and dangerous on account of horizontal seams and decomposed rock. The west heading here is of good Fordham gneiss which is sound and hard enough to be used for back filling and is delivered to the other headings for that purpose.

The tunnel sections are being constructed from open cut portals at Sedgwick Ave., at Cromwell Ave. and Inwood Ave., and from two headings from the Morris Ave. shaft 70 ft. deep and from Webster Ave. portal in a cut 35 ft. deep. The work is all of standard character and is executed with six top headings subsequently extended to full width and each followed by a single bench which is usually kept within 30 ft. of the heading. All of the drills, hoisting engines and other plant are operated by compressed air and the tunnels are lighted by electricity generated in each of the three principal power plants one of which is located at High Bridge, one at Inwood Ave. and one at Webster Ave. At the High Bridge plant one Ingersoll-Sergeant 20x24-in. straight line air compressor, and one Westinghouse electric motor for lighting service are installed and steam for them is provided by two 100-h.-p. Donnegan & Swift horizontal boilers. Air at 100 lb. pressure is piped along the open trench work and through the tunnel to the headings and operates the rock drills, pumps and hoisting engines.

Near the Inwood Ave. cut a similar plant is located and there are installed two 20x24-in. Ingersoll-Sergeant air compressors, one Westinghouse electric motor and two 120-h.-p. locomotive boilers and there is provided a machine and repair shop operated with compressed air and equipped with small machine and hand tools by which most of the repair and construction work for all the tunnels is done. A similar power plant at Webster Ave., supplies compressed air to the Morris Ave. shaft and to the Webster Ave. portal for the operation of all machinery there including two elevator cages and two 6-in. Cameron pumps. Smith shops are located at the top of each shaft or cut and near the portals and construction materials are stored at the different working points.

At High Bridge the ground was so bad that the beginning of the excavation was made by the crown bar method which was also required for a considerable distance east and west from the Morris Ave. shaft but the rock has improved so much in these headings that it has for some time been possible to replace the crown bars and poling boards with ordinary vertical and horizontal timber bents. In the east heading at the Morris Ave. shaft the rock is now so hard that timbering is unnecessary. The average present advance in each heading is about 125 ft. per month, and the total amount of tunnel excavation up to Feb. 1, was about 2,700 lin. ft.

Two Ingersoll-Sergeant drills mounted on columns are used in each heading, two more are used for extending it laterally and two mounted on tripods are used on each bench, the latter being kept about 30 ft. back from the heading. All holes are charged with 40 per cent. forcite and blasts are usually fired at the end of each alternate eight-hour shift, the miners and muckers alternating in the work which is maintained continuously day and night with an average progress of about 125 lin. ft. per month per heading.

The timbering is kept as close as possible to the heading wherever it is required, but in the west heading of the Inwood cut the rock is so hard that timbering is unnecessary and the results of test borings indicate that over considerable of the line timbering will not be required although it is now being placed in two other headings. It is framed on the surface of the ground near the tops of the shafts and is made entirely of 12x12-in. timbers cut to standard templates for the full centered arches used at Inwood avenue and High Bridge and for the flatter arches used at Morris avenue.

The headings in earth and very bad rock are timbered with bents averaging about 3 ft. apart which have horizontal caps and slightly inclined side posts of round timber with poling boards driven behind them for the roofs and sides. The lateral extensions are timbered in bad ground with poling boards over crown bars at the same level as those in the heading which are supported by vertical and inclined posts and braced with horizontal struts from center crown bars. In rock cuts, the extensions are timbered like the heading with transverse horizontal caps on vertical posts and neither lagging nor poling boards are required.

The arch roof timbers are carried on horizontal sills placed at the springing line and supported by vertical posts. In all cases the lengths of the timbers are reduced sufficiently to give sizes easily handled by two men. The concrete lining has not yet been commenced, but will be handled by simple methods and the roof arch will ordinarily have skewback seats cut for it in the sides of the untrimmed rock walls, thus relieving the side walls of the lining of any vertical load and permitting their thickness to be reduced to a minimum of 6 in., although the irregularities in the rock behind them will call for considerable additional concrete or backing for which payment is not allowed.

Muck is wheeled from each heading over a platform suspended from the arch timbers or carried on transverse beams to a point where it can be dumped directly into 1-yd. end or side dump wooden cars clear of the muckers working at the bench. The dump cars are drawn by a mule on 3-ft. gauge single tracks with sidings at the headings and at the shafts or portals where they are hoisted by boom derricks or cage elevators. At the Morris avenue shaft there are two elevator cages hoisting the cars to a trestle 10 ft. above the surface of the ground on which they are delivered to a spoil bank in the adjacent swamp to provide filling for improvements now progressing there.

The Webster avenue shaft is located near a number of store and apartment houses with large plate glass windows, many of which within a radius of two blocks were at first continually broken by the blasts in the heading. Near the portal very light charges were used but still damage was done by flying stones and by vibrations. As the headings advanced, the charges were increased and although the trouble from flying stones ceased, the windows were still broken and it was believed the trouble was due to the vibrations, but as a reduction in the size of the charges did not prevent it and as it was noted that the excavation was in rock, while the foundations of the houses injured were seated on earth, it was concluded that the trouble was due to direct concussion of the air.

The portal of the tunnel was closed with tight wooden doors intended to confine the movement of the air inside the tunnel. These were, however, immediately blown off by the blasts and were replaced by heavy doors of latticed plank leaving an opening of about one-half the total cross section of the tunnel through the interstices. A heavy rope mattress was also suspended transversely about 100 ft. beyond the portal and a 20x15-ft. vertical transverse wooden screen was placed in the cut with the upper edge at the surface of the ground and 25 ft. beyond the tunnel opening to serve as a baffle plate checking the air currents. These combined precautions have served to greatly diminish and practically stop the breakage of glass in the vicinity

All concrete is to be made with Portland cement carefully inspected and tested at the engineer's laboratory to fill the requirements of standard specifications. A thousand barrels of Giant Portland have been received and stored by the contractor and tested and accepted in readiness for use when the construction of the lining is commenced. Several Ransome and Smith concrete mixers have been provided ready for use at the different shafts and portals, and all concrete will be made of one of four classes, using approved cement, clean sharp sand, and broken screened trap rock retained on a ⅛-in. mesh, of varying proportions as follows: Class A, 1:2:4 with ¾-in. stone; Class B, 1:3:6, 2-in. stone; Class C, 1:2:2, ¾-in. stone; Class D, 1:3:6, ¾-in. stone. Wherever waterproofing is required, it is done with three layers of felt weighing 15 lb. per square, dipped in coal tar pitch and laid with 6 in. overlap in four alternate layers of coal tar pitch.

Work was commenced in March, 1906, and is required by the contract to be completed in 400 calendar days, a time limit which, however, is likely to be extended. The contract was based on unit prices for thirty classified items of work, the most important of which were estimated to contain about 78,000 cu. yd. of excavation, 20,000 cu. yd. of concrete of four different classes, about 440,000 lb. of steel reinforcement bars, 184 tons of structural steel, 22,000 lb. of castings exclusive of pipes, about 1,000 sq. yd. of waterproofing, 11,000 lin. ft. of piles, 218,000 ft. b. m. of timber and 4,500 cu. yd. of embankment. The total cost of the sewer computed in accordance with the estimated quantities is about $635,000.

The engineers' organization includes two field parties, a drafting and computing force, a cement testing laboratory and an inspector in every heading. The present staff consists of about twenty men, which will be increased to thirty as soon as the work is progressing at full speed.

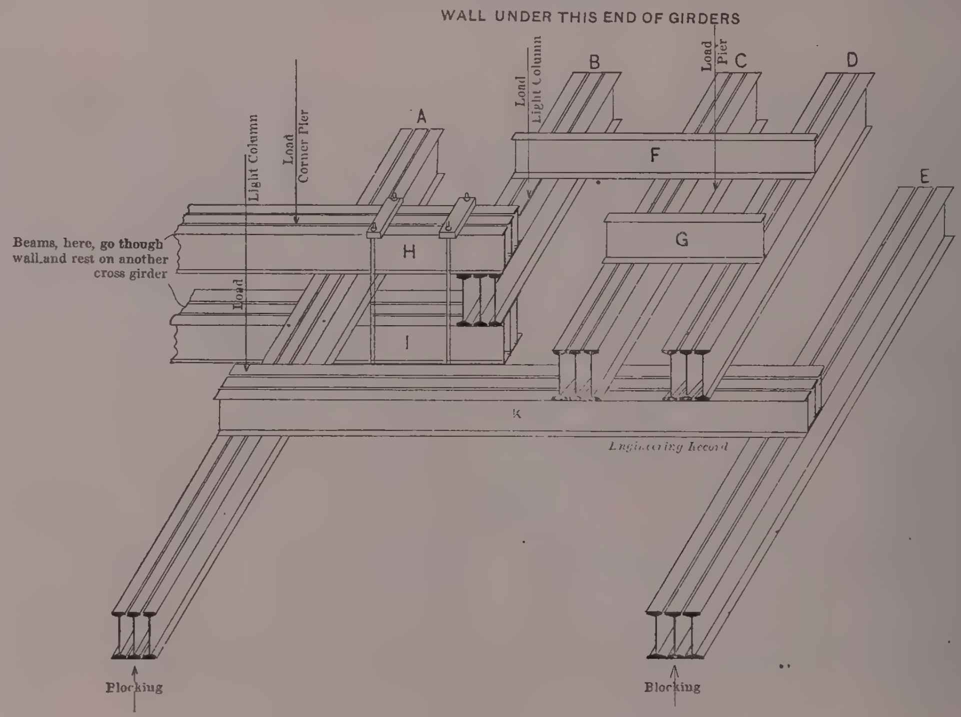
The sewer was designed and is being constructed under the general direction of Mr. Joseph A. Briggs, chief engineer of the Borough of the Bronx, by the Bureau of Sewers of the Borough of the Bronx, Mr. Charles H. Graham, engineer in charge; Mr. Josiah H. Fitch, principal assistant engineer, and Mr. G. L. Christian, assistant engineer in active charge of construction. The contract was awarded to Mr. William J. Flanagan, for whom Mr. James Judge is day superintendent and Mr. P. J. Dougherty, night superintendent. The work is being carried on with a total force of about 275 men, and up to Feb. 1 the total engineer's estimates amounted to about 36 per cent. of the entire estimated cost of the work.

Public Road Improvements in the Philippines by the insular government for the year ending June 30, 1906, cost $531,900, as against $618,900 during the previous year.

An Underpinning Job on the Washington Street Subway, Boston.

The accompanying isometric drawing, prepared by Mr. R. B. Farwell, assistant engineer, Boston Rapid Transit Commission, illustrates a method of supporting a building at a street corner over the excavation for the Washington St. tunnel in Boston. The case shown is a somewhat complicated one. The group of girders marked *A* is parallel to one street and is situated inside the basement close to the street line. They are supported by blocking on the finished tunnel structure at one end and terminate in a wall at the point where the letter *A* is placed at the other end, this wall being under the sidewalk and parallel to the other street line.

The *K* group of girders are supported on *A* and *E*, the latter being supported on blocking. Where *K* rests on *A*, a light column is carried. *H* and *I* are carried by *A* and run through a wall on to other cross girders, as the note on the drawing explains, *H* and *I* carry a heavy pier, the corner of the building, the former needling it and the latter supporting it underneath. *C* and *D* rest on *K* at one end and at the other end terminate in a wall under the sidewalk outside of the excavation. *F* and *G*, which rest on *C* and *D*, carry the weight of one of the piers of the building. The girders marked *B* end in the same wall as *C* and *D*, and a light column is supported by *F* and *B*. The work was done under the general supervision of Mr. Howard A. Carson, chief engineer of the Boston Rapid Transit Commission.

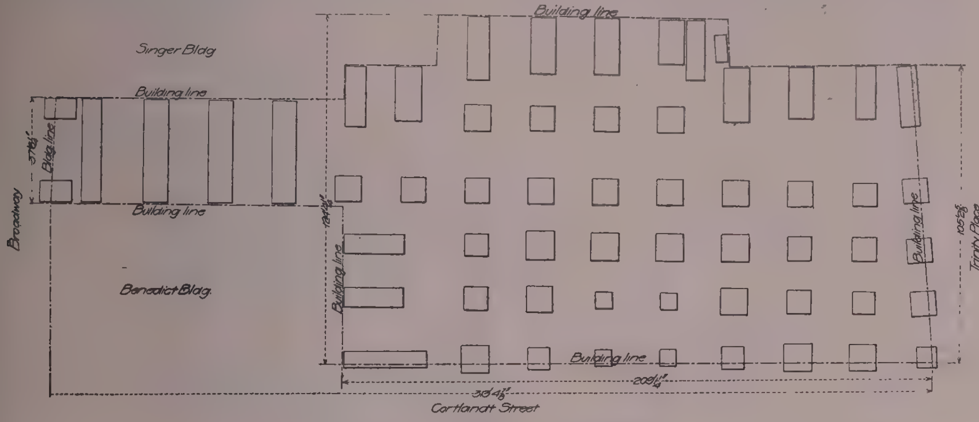


Needle Beams Supported on Girders.

A Large Reinforced Concrete Outfall Sewer has been designed by Mr. Calvin W. Hendrick for the Baltimore sewerage works. It is 11 ft. high and 12 ft. 3 in. wide inside. The radius of the invert is 24½ ft. and that of the arch intrados is 6 ft. 1½ in. The invert and sides are lined with 4 in. of brick. The concrete foundation is 12 in. thick, reinforced by ⅝-in. transverse bars on 9-in. centers and ⅝-in. longitudinal bars on 15-in. centers. The arch is 13 in. thick at the crown and has a ½-in. exterior plastering. It is reinforced near both inside and outside surfaces with ⅝-in. transverse bars on 9-in. centers. The longitudinal ⅝-in. bars near both surfaces are on 18-in. centers. The thickness of the side walls at the springing is 28 in.

THE PNEUMATIC FOUNDATIONS OF THE CITY INVESTING BUILDING, NEW YORK.

The thirty-two-story building for the City Investing Co., New York, has fronts on Broadway, Cortlandt St., and Trinity Place, with extreme dimensions of about 313 x 124 ft. on building lines, and will attain a height of 486 ft. above the sidewalk, thus exceeding any office building yet built or now under construction with the single exception of two contemplated towers rising above the main roofs of other new buildings. The estimated total cost of the building is $10,000,000; it has a contents of over 10,000,000 cu. ft., and will be built of brick, stone and terra-cotta supported on a skeleton framework of fireproofed structural steel which alone will weigh about 12,000 tons.



Plan of Caisson Foundations.

The total weight of the building, exclusive of the live load, is estimated at 86,000 tons, which, together with the vertical components of the wind pressure, develop maximum loads of 1,719 tons in single columns. In order to preclude any possibility of settlement, the column foundations are carried through earth, quicksand, clay, gravel and water into a solid stratum at an average depth of 80 ft. below the Broadway curb. The character of the soil and of the adjacent buildings was such that grillage or pile foundations or piers built in open excavation were impracticable or unsatisfactory, and it was decided to support all columns on 59 concrete piers with their footings carried to hardpan by the pneumatic caisson process. The location and dimensions of the caissons were determined by a very careful consideration of the architectural and engineering requirements and comparative estimates for different plans, from which the system shown in the accompanying diagram was developed and proved more economical and satisfactory than the alternative ones with which it was compared. The majority of the wall columns are seated on cantilevers described in The Engineering Record of Nov. 24, 1906. These carry them close to the building line and provide for the reactions by the weight of the interior columns, the total loads being transferred to the centers of gravity of single, comparatively long and narrow rectangular piers, which are located in the most convenient positions inside the building line. Each of these piers thus carries two columns, while the remainder of the piers are proportioned to carry single columns and usually have square cross-sections. The dimensions of the pier footings vary from 6 x 6 ft. to 8 ft. 6 in. x 37 ft. 4 in.

The buildings previously occupying the site were razed and the superstructures removed by a firm of wrecking contractors, and the contract for removing old substructures, making the excavation and building the new substructure was let with a time limit of 120 calendar days. The approximate amounts involved in this contract include about 4,500 cu. yd. of old masonry removed above the cellar floor, 11,000 yd. of excavation including the cellar floor and foundations of the old structure and 11,000 yd. of concrete in the new foundations.

The City Investing Co. building does not cover the entire area included by the three street fronts, but, as shown by the block plan previously published, lies between the Singer building extension and the Bourne Building on the south, and the Wessel or old Benedict building on the north. All of these buildings project beyond the extreme dimensions of the lot, forming reentrant angles, that of the Benedict building taking a rectanglar corner out of the new building.

View of City Investing Building Foundations, Looking toward Broadway.

The Singer extension building is now under construction and its foundations are also being built by the pneumatic caisson process, so that their safety does not demand consideration in this construction. Those of the fourteen-story Singer Building are supported on reinforced concrete platforms on the surface of the sand at a depth of about 25 ft. below the Broadway curb. They are of recent construction and massive character that is believed to afford such stability that they will be uninjured by the new foundation work.

The six-story Benedict building has about 170 lin. ft. of its south and west brick walls adjacent to the new building. They are about 30 in. thick and have rubble masonry footings of the same thickness seated on the sand about 18 ft. below the Broadway curb and 3 ft. above ground water level. Although a portion of them had previously been underpinned, they were found to be in very poor condition, with loose stones, cavities, and unreliable construction in many places so that it was not only necesary to underpin them, but to exercise great care and skill in supporting them to avoid danger of injury to the building on account of any disturbance to them.

Where the interior of the Benedict Building was accessible to the contractor, he entered the cellar and cut holes about 5 ft. apart through the foot of the brick wall just above the rubble footing, and inserted in them groups of three 15-in. I-beams about 20 ft. long tied together with iron yokes at both ends and supported in the cellar on sills parallel with the outer wall and about 6 ft. from it in the clear, laid on the concrete cellar floor.

At the outer ends, each group of needles was carried on two 20-ton jack screws set in the upper ends of two 12 x 12-in. vertical shores and reacting against horizontal steel plates on the lower flanges of the needle beams. The shores were set about 7 ft. clear of the face of the wall and were seated on 5 x 5-ft. grillages of 12 x 12-in. timbers, distributing the weight over the area of a concrete footing 3 ft. deep laid in the bottom of a pit 5 ft. square sheeted down from the old cellar floor to the level of subgrade. The jack screws were operated until the needlebeams took bearing on the brickwork and were followed up with blocking and wedged under the outer ends of the needlebeams.

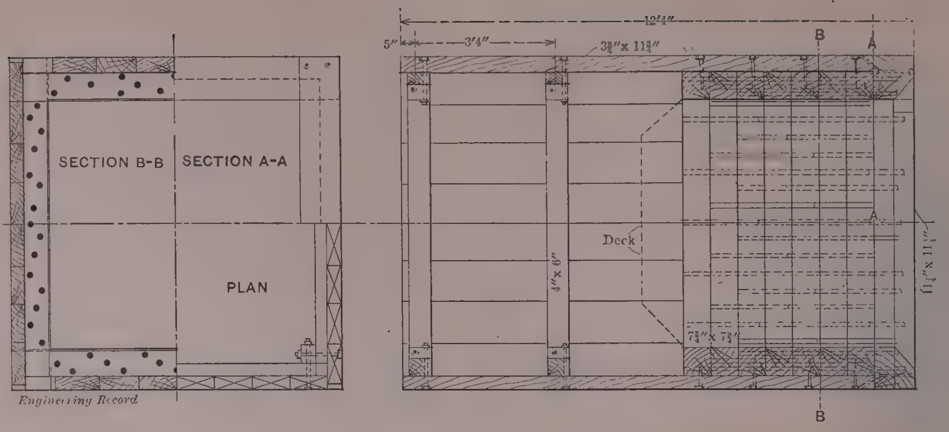
Narrow excavations were made between the old wall and the sheeted pits and the latter were braced against the face of the masonry as the excavation proceeded. When it reached the bottom of the old footing, small drifts were extended under it and in them "springing needles," each consisting of a pair of 12 x 12-in. horizontal timbers bolted to the vertical shores, were inserted with their ends bearing against the botom of the old footing. Vertical chains with turnbuckle adjustments were attached to the I-beam needles above, close to the face of the wall, and engaging the springing needles formed fulcrums for the latter which acted as cantilevers supporting the footing below the main needlebeams. A vertical strut was inserted between the ends of the springing beams and the I-beam needles to relieve the connection to the vertical shores and take the upward cantilever reaction. Afterwards, a trench was excavated alongside and underneath the old footing and was sheeted under the Benedict building by vertical poling boards driven down as the work progressed until the excavation was carried to subgrade of the new building.

For a length of about 60 lin. ft. of the wall, access could not be had to the interior of the Benedict building and it was therefore supported entirely from the outside by figure 4 needles. Here pits 5 ft. square and 5 or 6 ft. apart on centers were excavated to about 30 ft. below the Broadway curb and a permanent footing of concrete 3 ft. thick was laid in the bottom and covered with a wooden grillage on which were seated 12 x 12-in. inclined shores about 30 ft. long. Both ends of these shores were cut square, the upper ends being gained into recesses cut in the brick walls of the Benedict building.

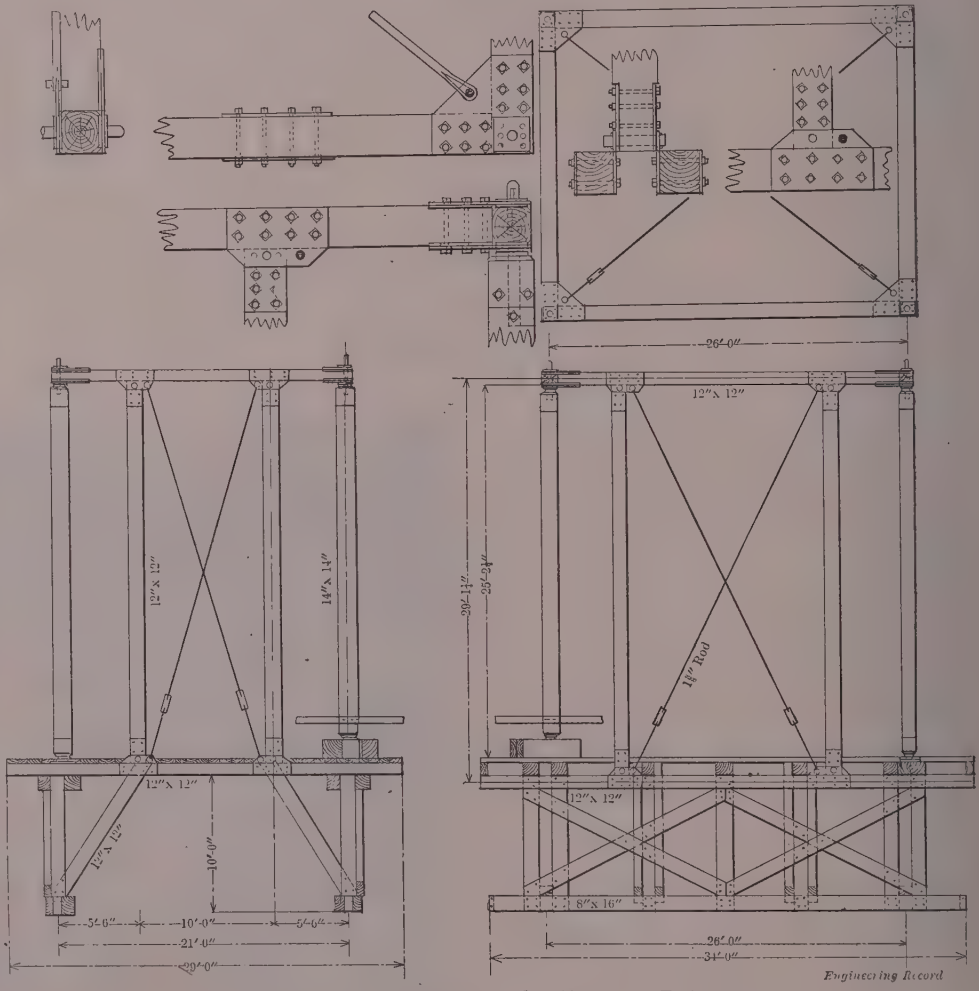
The lower ends were seated on short horizontal timbers supported on one or two jack screws reacting against the inclined surfaces of foot blocks distributing the pressure over the grillage. Where two jack screws were used, pairs of wedges were inserted between them and driven to take up the load as fast as the jack screws were operated and where only a single screw was used, pairs of wedges were set on both sides of it for the same purpose.

Excavation was carried down between the sheeted pit and the face of the wall to the bottom of the old footing and small drifts were made under it to receive springing needles like those already described. Their inner ends were set under the wall some 6 to 9 ft. below the cellar floor in the Benedict Building and the outer ends were bolted to the feet of the inclined shores and took bearing against reaction cleats securely bolted on above them. Horizontal steel saddle plates on the upper ends of the inclined shores afforded bearing for suspenders made with 1-in. vertical rods and chains provided wth turnbuckle adjustments and engaging at the lower end the springing needles for which they provided fulcrums.

The jackscrews and turnbuckles were operated until the weight of the wall, estimated to be 12 tons per lin. ft., was transferred to the concrete footings in the bottom of the pits, after which the excavation underneath the wall footings was made and the new footing was built under it, as for the portion carried by the horizontal needlebeams, and connection between the old and new masonry was made in the usual manner with pairs of bearing stones and sets of wedges, the latter being driven from time to time until all danger of further settlement from the new caisson work was past.



Square Caissons Used at City Investing Building.



Traveler With Clearance for Wagons Below.

After the underpinning was completed, the removal of the old masonry walls and footings was finished and involved a large amount of work in taking out the old cellar floor which virtually formed a platform of solid granite and concrete masonry 6 ft. thick, built with large rectangular piers connected by inverted arches and intended to distribute the weight of the old building over the entire area of the ground occupied. This masonry was very strong and massive and its removal required blasting, involving the operation of nine steam drills for about two months, during which time thousands of cubic feet of granite were removed from the old substructure.

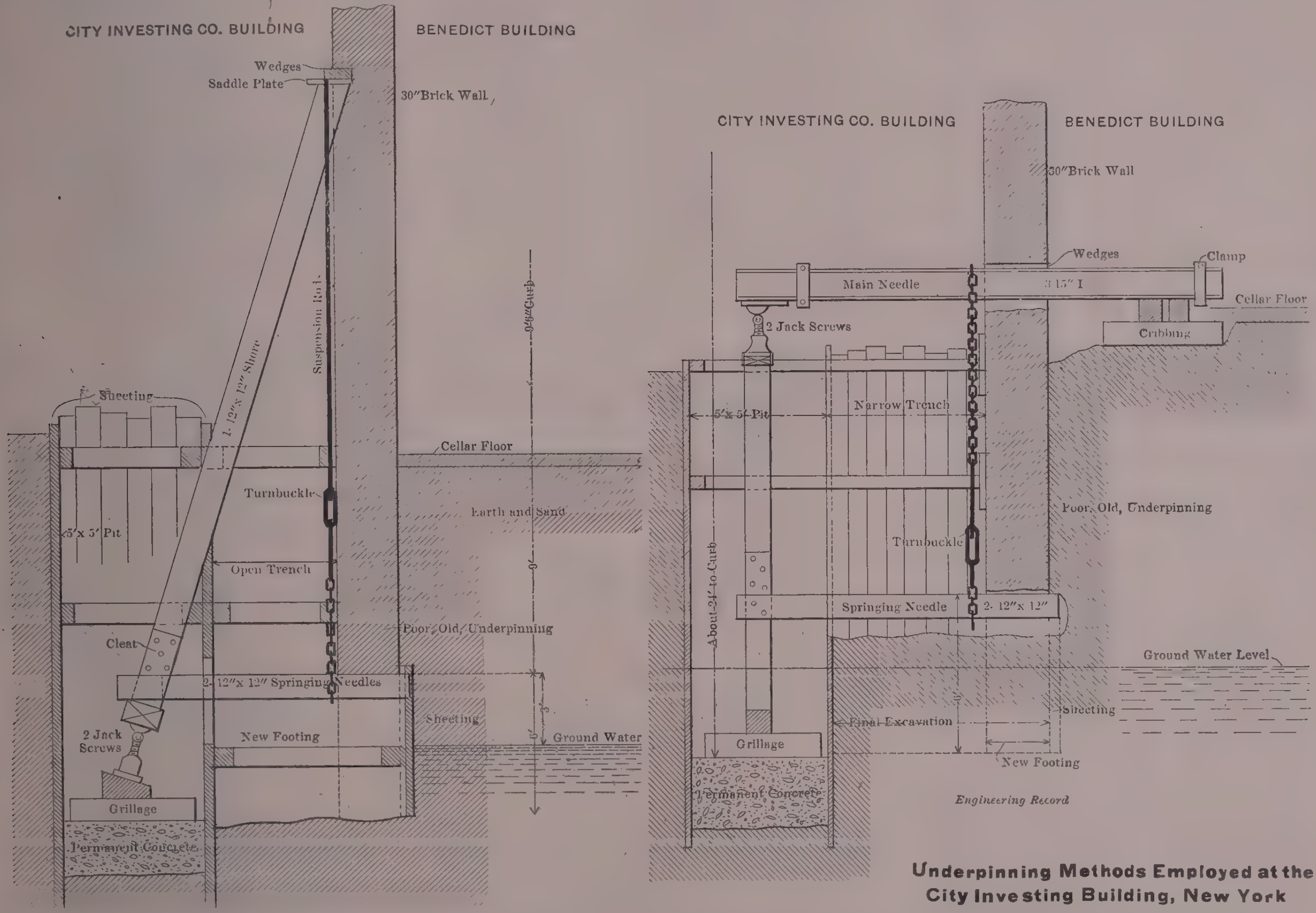
The general excavation was carried down about 24 ft. below the Broadway curb except in the boiler room where it is 30 ft. deep, and wagon platforms about 24 ft. wide were built at street level to provide for the delivery of materials and the removal of spoil from the caisson excavations. One platform over 300 ft. long is continuous through the lot from Broadway to Trinity Place, another about 150 ft. long is parallel to it midway between it and Cortlandt Street and reaches from Trinity Place to a transverse platform about 75 ft. long close to the Benedict Building, connecting the long platform with Cortlandt Street.

Each platform is supported on one center and two side rows of piles, the outer ones being on the lines of the 21-ft. gauge traveler track rails parallel with Cortlandt Street. The piles are arranged to clear the caissons as much as possible and where this cannot be done, timber posts seated on bottom sills are substituted for them so that they may be easily removed when necessary for sinking the piers. As Cortlandt Street slopes down about 7 ft. from Broadway to Trinity Place, and it was necessary to maintain the surfaces of the platforms horizontal, the long platform was built at two levels, one end of which corresponds to the Broadway curb and the other with the Trinity Place curb, thus making it impossible for wagons to go through from either end to the other.

A traveler was erected on each of the longitudinal platforms and consists of a 21 x 26-ft. timber tower 12 ft. high arranged with a transverse clearance of 18 ft. horizontal and 10 ft. vertical, through it to enable wagons to pass under it and provide an engine platform covering the whole area above where there are installed four derrick booms 45 ft. long with 15 tons capacity, each of them operated by a Lidgerwood hoisting engine. In some instances, the engines are the ordinary flat type seated on the deck of the traveler and swinging the boom horizontally by means of the standard auxiliary drums and cables engaging the bull wheel.

In four cases the engines are of the new type with vertical bed plates bolted directly to the mast and mitre geared to short vertical shafts with lower pinions engaging circular racks bolted to the deck so that the boom is swung directly by the hoisting engine without the bull wheel or operating cables. This device has been found very satisfactory on account of its positive action and the absence of any lost motion or unnecessary movement, the boom being controlled with great accuracy and rapidity.

There are also three small stiff-leg derricks located wherever required in the lot to handle materials not conveniently reached by the travelers. All of the hoisting engines are operated by 25-h.-p. electric motors and an important feature of the installation is that with one or two unimportant exceptions, all machinery is operated by General Electric motors. They are driven by current purchased from the New York Edison Co., and have given great satisfaction both in regard to reliability and convenience. It is not possible to give an exact comparison of the cost of electricity and steam for the total power used measured in units of excavation or concreting.



Underpinning Methods Employed at the City Investing Building, New York

Electricity purchased by meter would probably be more expensive than steam also purchased by meter, but in consideration of the impossibility of providing convenient room for a steam power plant to enable the contractor to produce his own steam and further considering the saving effected by the more economical attendance required for the electric motors and the other conveniences of the installation, it is considered that the electric service is more desirable and profitable than steam service for the contractor under the conditions which here obtained. In the operation of the hoisting engines where the service is intermittent the actual cost of electricity is probably less than that of steam, while on the other hand the operation of the air compressors under a comparatively large and constant duty is greater for electricity than for steam.

Small wooden buildings were located under the platforms and wherever clearance was found between the caisson sites, for the smith shop, electricians, shop, pipe shop, riggers and carpenters and for the air compressors, for general storage, and for the sand-hogs' dressing-room. The office building was located above the compressor house. Space being everywhere very much limited, all accommodations were condensed as much as possible.

As the stone quarries are closed in the winter season, a large quantity of broken stone was purchased in the summer and about 1,800 yd. of it were stored in the excavation and delivered as required by wheelbarrow to one large Ransome concrete mixer and three small ones. Cement was delivered in lots of about 1,000 bags, stored in a building located under one of the wagon platforms. Quantities of sand were delivered at frequent intervals and dumped into heaps at the bottom of the excavation. The large concrete mixer is located near the center of the long working platform just above its level and has a fixed hopper charged from barrows wheeled to it up a short incline. Its product is delivered to the different caissons in buckets handled by the derrick booms of the travelers. The small concrete machines ars transferred by the derrick from place to place to mix the concrete where required adjacent to any given caisson. The large machine is operated by a 25-h.-p. electric motor and the small ones are operated by 15-h.-p. motors.

The area of the building is so crowded with the caissons and contractors' plant that no room was found for service tracks and all materials are handled to and from the wagons directly by the derrick booms. Air pressure at a maximum of about 32 lb. for caissons and 100 lb. for pneumatic tools is provided by six Ingersoll-Rand machines, two of them driven by 110-h.-p. electric motors and four operated by steam. Artificial illumination is provided by four Excello arc lights and a large number of incandescent lamps. Very little difficulty has been encountered with water and all drainage has been effected by two small Cameron steam pumps and two small Worthington centrifugal pumps driven by electric motors.

All of the foundation piers are built above the surface of the ground on the decks above the working chambers of the pneumatic caissons. The concrete is deposited in sectional moulds removed from the bottom and placed above as the work progresses. In most cases the concreting was entirely finished before excavation was commenced in the working chambers in the caissons, but in some cases excavation was commenced and the caissons were sunk a few feet to give additional lateral stability for the tall shaft and to relieve the excessive weight on the walls of the working chamber, after which the excavation was stopped and the upper part of the pier completed before sinking was resumed.

The caissons have a uniform height of 12 ft. 4 in., the lower 7 ft. serving as a working chamber and the upper part as a permanent cofferdam enclosed at the bottom with a temporary wooden deck supported on cleats and shores to carry the first section of the concrete, and removed after it was properly set. The accompanying cross-sections show the principal features of a typical caisson and served for the construction of 31 caissons with dimensions varying from 6 to 10 ft. wide over all.

The caisson is symmetrical around the longitudinal and transverse axes and is built throughout of long leaf yellow pine, planed on all sides and calked below the deck of the working chamber. The main walls are built of solid courses of 8 x 8-in. timbers dressed to 7¾ in. and secured together by ⅞-in. vertical drift bolts passing through three courses. They are seated on the 12 x 12-in. bottom course with the inner side chamfered 6 in. to make a cutting edge which is not reinforced with steel. The upper corner of the outer course engages the lower ends of 4-in. vertical sheathing planks planed to 3¾-in., which extend beyond the roof of the working chamber to form the continuous walls of the permanent coffer dam braced by two sets of inside horizontal frames.

Some of the caissons were made with walls of 4-in. vertical planks bolted to inside rectangular horizontal flanges about 2 ft. apart vertically.

They were made with 3 x 3-in. angles connected by horizontal gusset plates at the corners. The cutting edge was made with a 12 x ⅜-in. plate reinforced by a 3½ x 3½-in. angle on the lower edge. When the full height piers were built on these caissons before sinking was commenced, the weight of about 23,000 lb. per lin. ft. on the 4-in. walls was found excessive and sinking was commenced before the concreting was finished or heavier walls, like those shown were adopted.

Above the tops of the caissons, the concrete was deposited in 8-ft. courses placed in forms made with four panels 8 ft. high corresponding to the sides of the pier. Each panel was made with 2-in. vertical planks bolted to horizontal exterior 3 x 3-in. angles about 2 ft. apart vertically. The ends of the angles projected beyond the planks and their horizontal flanges were bolted to gusset plates, thus connecting the walls of the form so that they could be very quickly assembled or stripped from the finished concrete. The horizontal angles formed top and bottom flanges which served for the connection of the successive sets of forms, the lower one being removed after the concrete was three days old and bolted to the upper edge of the top form.

As the piers are sunk below the bottom of the excavation, the upper ends are provided with temporary wooden cofferdams 6 to 8 ft. high which are made similar to the forms except that the horizontal angles are inside to avoid obstruction in sinking. These cofferdams afford opportunity for setting the grillages and steel columns, after which they can be removed and the concreting and back filling done over the tops of the piers.

All caissons were made at the contractors' yard on Long Island and were delivered to the site on trucks. Some of them were brought across the Williamsburg Bridge and others, too large to clear that structure, were ferried across the river on lighters and transferred from them to trucks drawn by eight teams of horses. They were all unloaded and set in position with single booms of the traveler derricks. All of them were handled without difficulty, but when the heaviest ones, weighing 14 tons, were lifted, it was necessary to increase the stability of the traveler by anchoring the side opposite to the derrick in service. This was usually done with great ease by attaching the hoisting tackles of the opposite boom to the trestle work of the traveler track and setting up enough on the tackle to make it snug. The pier concrete was made 1:2:4 up to the top of the caissons and 1:3:5 above that level. Northampton Portland cement being used for both mixtures.

The caissons were sunk usually to a depth from 6 to 12 ft. before the working chambers were put under air pressure. As the tallest of them were about 44 ft. high with bases 7 or 8 ft. wide, their stability was relatively small and they were handled with great care, suitable collars and braces being provided to prevent them from getting out of plumb. Where they were located under the wagon platforms, it was impossible to build them at first to full height and they were therefore built in single courses and sunk a few feet and additional courses built on top as clearance was provided for them. Before the air pressure was admitted to the working chambers, the caisson excavations were drained by steam siphons. The excavation was made with shovels and did not require blasting.

Much of the fine dry sand encountered was removed from the working chamber by the dry blow-off process. A 3-in. vertical tube terminating at the top with a goose-neck reaching over the upper edge of the cofferdam or concrete form was carried down through the deck of the working chamber and terminated at the lower end near the cutting edge with a fullway valve, a reducer and a short section of 2-in. flexible pipe. The extremity of this pipe was buried in loose sand, which, when the valve was opened, was readily forced up the pipe and discharged outside to its goose-neck by the pressure of the air in the caisson. The contracted size of the inlet diminished the total weight per square inch of the ascending mass to an amount less than hydrostatic pressure.

Boulders, lumps of earth, and other materials which did not pass through the pipe blow-off were hoisted in the usual manner in 30-in. cylindrical steel buckets 3 ft. deep with their hoist lines passing through stuffing boxes in the doors of the air-locks and attached to boom hoists. The bottom of the bucket was provided with a ring and a trip line and the contents were dumped directly into wagons or were emptied on the platform and shoveled into the platforms at convenience, no room being available for the use of overhead storage bins.

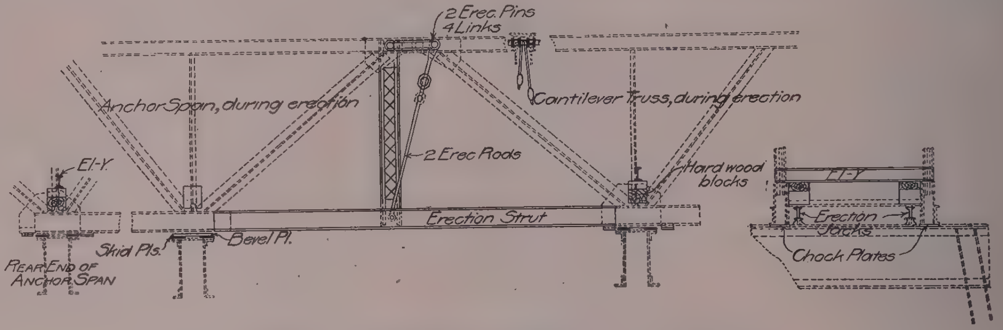
All of the caissons were sunk to an average depth of 6 ft. below the surface of the hardpan about 70 ft. below the Broadway curb. The greatest depth was 80 ft. The most rapid sinking was at the rate of 2 ft. an hour for some of the smaller caissons and as many as six caissons were under pressure simultaneously. All caissons were fitted with the O'Rourke air lock, having doors made in double leaves hinged so as to recede when open into recesses and provide full clearance for the material buckets. Air pressure was put on the first caisson Nov. 7, and on January 23, twenty caissons had been sunk and concreted and sixteen more were in place.

The work has been carried on with an average force of 275 men in the day shift and 100 men in the night shift besides three 20-men shifts of sand-hogs maintaining continuous work in the caissons. When the temperature is much below freezing, the concrete is mixed with salt water and the forms are covered with canvas under which exhaust steam is discharged and no difficulty is experienced from freezing.

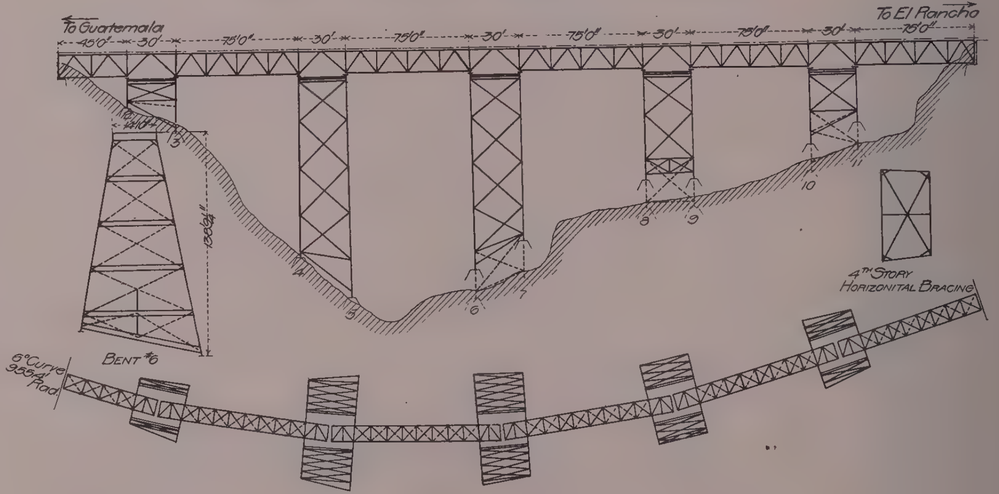
Mr. Francis H. Kimball is the architect, Weiskopf & Stern are the consulting engineers, and the substructure contractor is the O'Rourke Engineering Construction Co., Mr. Oscar Erlandsen, M. Am. Soc. C. E., chief engineer; Mr. Frank C. Shepherd, M. Am. Soc. C. E., general superintendent, and Mr. Frank W. Webster, superintendent.

Erection of El Rodeo Viaduct, Guatemala Railway.

The El Rodeo viaduct on the Guatemala Ry., illustrated in this journal on Feb. 16 of this year, is a single-truck structure about 571 ft. long, with six riveted truss spans 12 ft. deep supported on two abutments and five steel towers of a maximum height of about 139 ft. The towers have a uniform length of 30 ft. and receive on their transverse top girders the lower chords of the trusses, which cantilever beyond them to the centers of the towers where the top chords of adjacent spans abut. This feature of the construction, as was described in the previous article, eliminates the usual tower spans and reduces the bearings on the tower girders so that only a single truss is supported on the same girder seat, thus not only affording more room for bearing, but providing clearance for free longitudinal and transverse movement of the trusses during erection.



Details of Temporary Cantilever Anchorage.



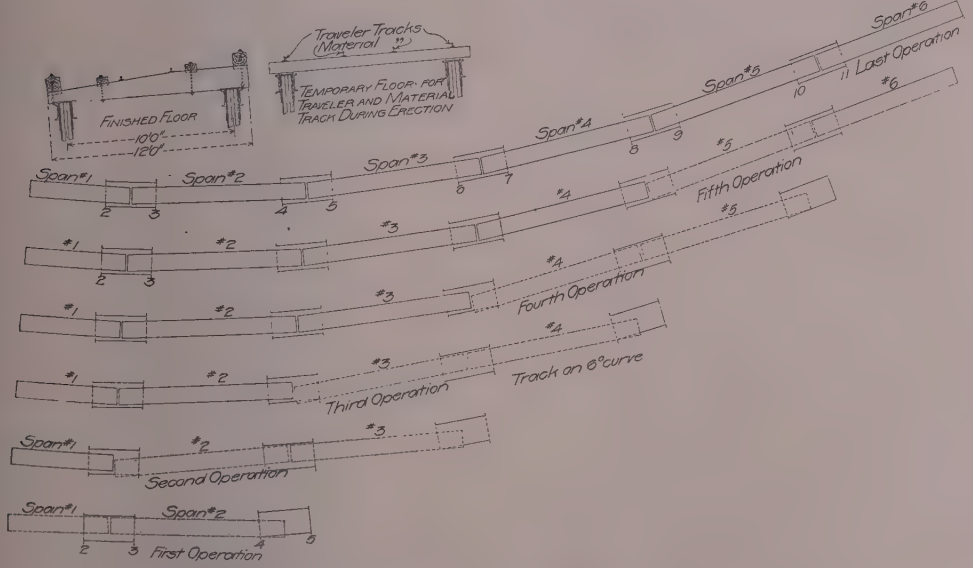
Elevation of Viaduct Without Tower Spans.

This consideration was a controlling reason for adopting this construction, inasmuch as the viaduct is on a 6-deg. curve and it is planned to erect it by the cantilever system, each span serving as an anchor arm for the next in succession. In order to fulfil this requirement, the span being erected and the span last finished must have their axes in the same line, and as the center lines of the spans in their final positions form chords of an arc of 955½ ft. radius, it is necessary to move both trusses from their final position in order to get them in the same line and to still keep them within the limits of the tower tops, which are slightly extended to meet this requirement.

The complete process involves three positions for each span, the first being that in which it is erected from the preceding span, the second that in which it serves for the erection of the succeeding span, and the third when it is placed in its final position. In the first case, its axis is deflected to the exterior of the curve, in the second to the interior, and in the third it is brought to coincide with the chord of the curve. Spans 5 and 6 are on a tangent, therefore it is only necessary to place span 5 in two positions, first in line with span 4, and afterwards in its permanent position, while span 6 is erected at first in its final position. The successive positions of all spans are clearly indicated on the diagram showing the successive stages of erection.

The viaduct is erected by an overhead steel traveler illustrated in the description of the Las Vacas viaduct, in The Engineering Record of Feb. 2. It has a 45-ft. wheel base with trusses 10 ft. deep ,allowing clearance between them for delivering materials on top of the finished viaduct. It has two 60-ft. steel booms and one 20-ft. wooden boom with which the members are unloaded from the service cars and assembled in position. For this service it is provided with a counterweight composed of rails or viaduct members in the plane of each truss at the rear end. The total computed uplift at the rear wheels is 16,000 lb., for which 32,000 lb. of counterweight, including the engine and boiler, or an adequate anchorage to the finished structure, is provided.

The first operation in the erection of the viaduct is to assemble and equip the traveler ready for use on grade at the west end of the viaduct. With it bent No. 2 of the first tower is erected and the first span is erected on it and on the abutment. Tower bent 3 is erected and the tower completed. A temporary bearing for the lower chords of span 1, on the transverse girder of bent 2, is provided by shoe plates inserted between the bottom flanges of the chord and the girder. These plates are slightly beveled to correspond with differences in elevation of the ends of the girder during erection, and are seated on temporary track plates placed on the top flanges of the tower girder so as to form a smooth continuous surface over the rivet heads and provide for swinging the span easily back and forth on the tower.

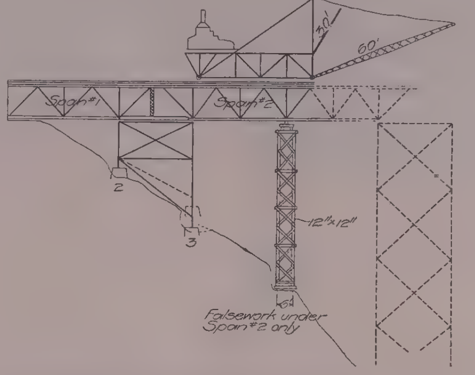


Successive Positions of Spans Showing Displacements for Anchorage.

The end of span 2 is erected on bent 3, and cantilevers back to the center of the tower, where it meets the cantilever end of span 1, and is connected to it by four welded loop links, previously used in the Las Vacas viaduct, which engage temporary erection pins through the extremities of the top chords. The ends of the bottom chords, as shown in the accompanying detail, are connected across the tower by a special temporary erection strut made of a pair of channels back to back with their webs splice-bolted to the ends of the lower-chord channel webs and virtually forming a continuation of them.

At the center of this strut a vertical post is pin-connected to the end of the top chord in span 1. The pin through the lower end of this vertical post and the strut also receives the ends of a pair of rods slightly inclined to the vertical, which are fitted with turnbuckles and have loop eyes engaging the pins through the top chords of span 2. These temporary members complete two panels between the adjacent spans and virtually form part of a continuous girder system across the top of the tower, and provide for the transmission of the erection stresses to the completed span.

The lower chords of the trusses are seated on the tower girder with shoe plates and track plates like those used for bent 2, and batten plates are bolted across the lower flanges of the bottom chords on both sides of the tower girder, so as to limit the longitudinal displacement of the trusses. The traveler is advanced and erects the first half of span 2 and the falsework tower between bents 3 and 4. This tower is built from material previously used for a similar tower in the Las Vacas viaduct and is proportioned for a reaction of 150,000 lb. The blocking on top of the tower is wedged to bearing with the bottom chords of the trusses; the traveler is advanced to the position shown in the diagram, erects the remainder of span 2 by the cantilever method, and erects tower 4—5.



Erection of End Span with Falsework Tower.

The traveler is anchored or blocked securely to prevent its longitudinal movement on the track. Track plates and shoes are placed in position on the cross girder of bent 4 and a horizontal 10-in. I-beam is bolted across the vertical members of the trusses in the plane of tower bent 4. Hardwood blocks are notched over the vertical flanges of the lower transverse strut and are fitted tight against the bottom flange of the I-beams. A 50-ton jack is then placed under these blocks at each end of the strut, and being operated reacts against the I-beam and lifts the forward end of span 2. This releases the links connecting the top-chord pins of spans 1 and 2 and they are removed together with the horizontal and vertical struts and adjustable tie rods.

The forward end of span 1 is skidded to final position by horizontal jacking and is lifted by jacking against a reaction beam in the plane of bent 2, as described for span 2 on bent 4. This releases the shoes and skid plates, which are removed and the span lowered to its final position on bent 2. Span 2 is skidded from its original position, in line with the first position of span 1, to its second position as indicated in the general diagram with one end on the outside of bent 3 and the other end on the inside of bent 4. The bottom flanges of the lower chords are bolted to the girder of bent 4 to provide an anchorage for the computed uplift of 6,000 lb., for which a factor of safety of two is required.

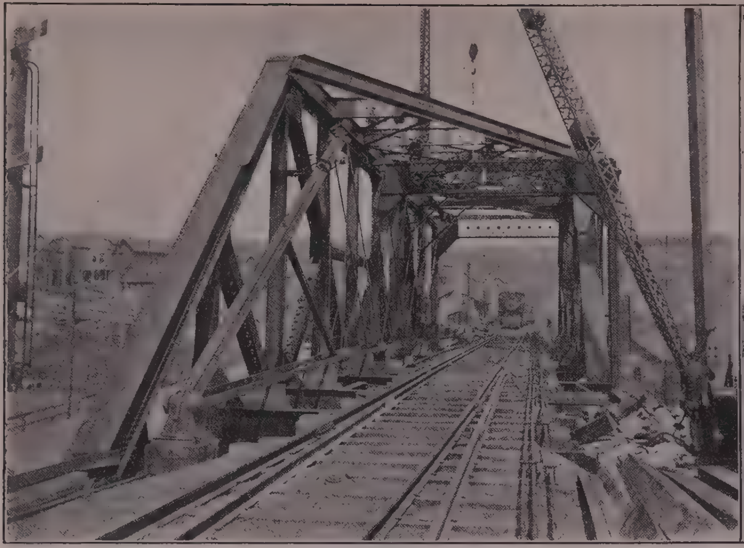
The first end of span 3 is erected on bent 5 and is connected to the end of span 2 with the links and struts brought forward from tower 2—3. The traveler advances and erects span 3 as a cantilever without the use of any falsework intermediate between towers 4—5 and 6—7. The traveler is anchored on span 3 and erects towers 6—7, placing the skid plates and shoe plates on bent 6 which had been removed from bent 2. The jacking-beam and blocks removed from span 1 are fitted to span 3 over bent 6, and the forward end of the span is jacketed up and the erection links, struts and other material connecting spans 2 and 3 are released and removed.

Span 3 is lowered to bearing on skid plates and is shifted transversely to its second position in readiness to act as an anchor arm for span 4. The rear end is anchored, span 2 is shifted to its final position, the ends are jacked up, shoe plates and skid plates removed, and it is lowered to bearings and finally secured. The erection of the remaining spans and towers is proceeded with by a repetition of the cycle of operations already described, special care being taken always to provide the required counterweight or anchorage for the rear of the traveler and for the rear of each successive span as it becomes in turn an anchor arm for the span in advance.

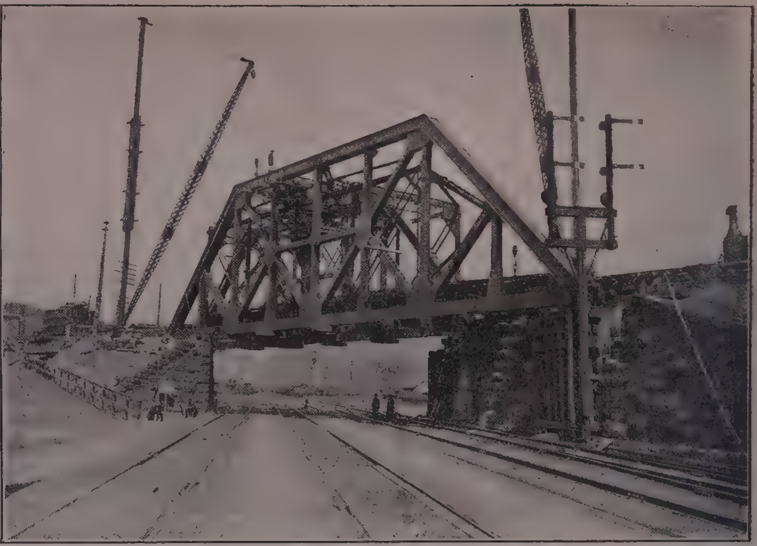
The super-elevation of the outer rail in the track required on account of the curvature is provided by using tapered ties resting on the top chords of the trusses. During erection, these ties are turned flat and used to carry the traveler rack on the centers of the trusses. Boards 1 in. thick and just wide enough to fit between the rivets in the edges of the cover plates of the top chords are used as fillers under the ends of the ties to lift the latter clear of the rivet heads.

The viaduct was designed by Mr. V. G. Bogue, New York, Mr. W. H. Kennedy and Mr. A. W. Buel, associated engineers on railways and bridges respectively. Mr. S. F. Shaw is chief engineer, and Mr. J. H. Pope, bridge engineer of the Guatemala Ry. The Baltimore Bridge Co. is the contractor for the steel work, and Mr. W. T. Penny is the contractor for erection. The method of erection was worked out in detail by Mr. Buel, assisted by Mr. E. M. Rosenberg, who suggested the substitution of the cantilever panels in place of the tower spans, in consultation with Mr. Kennedy.

Good Puddle for core walls in reservoir embankments requires about 20 per cent. of water to be mixed with the clay, according to Mr. Wm. Watts in a paper before the Yorkshire Students of the Institution of Civil Engineers. Before the puddle regains its natural clayey condition in the wall, the excess of water must be forced out by compression, in order to increase the density of the wall and make it more impervious. In order to allow the escape of the excess water the material in the sides of the trench in which the wall is started must not be too impervious.



Position of Old and New Spans During Erection.



Derrick Erection o New Span without Falsework.

ERECTION OF THE LEHIGHTON BRIDGE OF THE CENTRAL R. R. OF NEW JERSEY.

In the fall of 1905 and the spring of 1906 the Central R. R. of New Jersey renewed its double track through skew bridge at Lehighton where its tracks are carried over the Lehigh Valley R. R. This point is the throat of the Lehigh Valley Packerton yard, and switching is being constantly done beneath the Central R. R. bridge. The old bridge was a 115-ft. Phœnix column span built by the Phœnix Bridge Co. in 1888 and was designed for two 85.5-ton engines followed by a train load of 3,000 lb. per lineal foot on each track. The old span has been in continual use since 1888, carrying heavy fast passenger and freight trains, and was very light for the present traffic.

The new bridge is a double-track, through, riveted-truss, skew span, 128 ft. center to center of end pins, designed for the Central R. R. standard loading of two 187½-ton engines followed by a train load of 5,000 lb. on each track, and is on a 0.2 per cent. grade rising west. The old span was skewed 55 ft. in 27 ft. 6 in.; the new span is skewed 48 ft. in 29 ft. 4 in. The new span was lengthened 13 ft. to take out some of the excessive skew and to make the stringers at the ends of the span of the same length under each track for convenience of laying ties and maintenance of track.

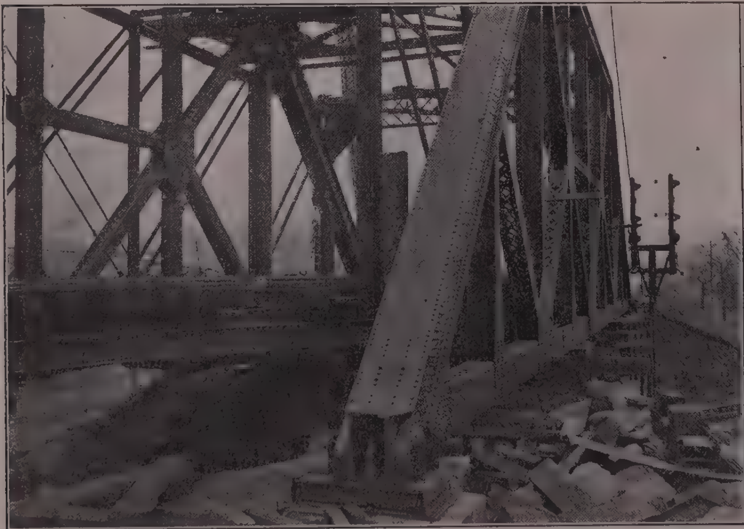
The new span was designed with a view to the ease of erection. Its general features correspond closely with those of the Jefferson St. bridge, illustrated in The Engineering Record of Feb. 16. The top laterals and struts were made in two sections, the top portion being put in position above the old truss and the bottom portion being put in position after the old truss was taken down. The panel lengths were spaced with reference to the replacing of the old floorbeams by the new. At the bottom chord at the second panel point from the east end of the north truss the old floorbeams interfered with placing the new gusset plates and sub-diagonal, and temporary gusset plates were used and the sub-diagonal was omitted until the old floorbeams were removed, when the final gusset plates and the sub-diagonal were placed in position.

The skew is so great that at each end of the span the two last floorbeams are connected at one end to the truss and are seated at the other end on the abutment masonry, as shown in the floor plan. The masonry ends of these floorbeams are braced longitudinally by the stringers and bottom laterals and have sole plates riveted to their lower flanges. At the expansion end, the sole plates have longitudinal guide strips engaging nests of rollers placed on bed plates bolted to the masonry. At the fixed end, the sole plates are seated on bed plates built up to a thickness of 4¾ in. to compensate for the rollers at the opposite end, and made with alternate crossed layers of narrow bars riveted between top and bottom plates. As the south truss was erected 39 in. south of its final position, one of the end floorbeams was not long enough to reach bearing on the oblique abutment wall, and it was temporarily extended by a girder 4 ft. 10 in. long, bolted to the end of the web and projecting 2½ ft. beyond it. The depth of this girder was made equal to the clear distance between the flange angles of the floorbeam and its flanges were made with single outside angles so that its web engaged the web of the floorbeam. At the outer end it was bolted to the new stringer and was supported on blocking fitted to the lower flange of the temporary extension.

The Lehigh Valley R. R. had recently installed an interlocking plant in their yard at this point. Between the abutments of the Central R. R. bridge their tracks were spaced a little over 12 ft. apart on centers with several switch points coming directly beneath the bridge. As these tracks were greatly congested it was not deemed advisable to place any falsework between them underneath the bridge. Any falsework so placed would have deranged their interlocking system and would have complicated and interfered with the train movements.

The problem was to take down the old Central R. R. bridge and erect a new span in its place without interfering in any way with the Lehigh Valley R. R. traffic and with as little interference as possible with the Central R. R. traffic.

The clearance of the Lehigh Valley R. R. at the bridge is 17 ft. above the top of the rail and during the erection of the new span a 16-ft. clearance had to be maintained. The depth of the new floor system is 3 ft. 9 7-16 in. from the



New South Truss in Temporary Position on Cantilever Beams.

Completed Double-Track Skew Span.

base of the rail to underclearance. The depth of the old floor system was 3 ft. 8 in. In order to install the new span it was necessary to raise the old bridge a sufficient height to swing the new bottom chord under the old floor system and support it there, still keeping the 16-ft. clearance over the Lehigh Valley R. R. tracks.

The only falsework placed beneath the bridge was a timber tower with a 5x17 ft. base, at the southeast corner between the tracks and the abutment, where the Lehigh Valley R. R. tracks were far enough from the abutment to safely clear it. This tower was used to carry the southeast corner shoe of the new truss in its temporary position, and was removed as soon as the span was jacked over to its final position.

The changes in the masonry to fit the new span were made by the Maintenance of Way Department, which also built the grillages into the abutment, and raised the track on the approaches. As soon the the Central R. R. Co. started work on the masonry they installed a temporary interlocking plant and gauntleted their tracks in the center of the old bridge, with 8 in. between adjacent heads of rails, and ran single track across the bridge with speed reduced to four miles per hour. They then finished the main changes in the masonry and built in the steel grillages.

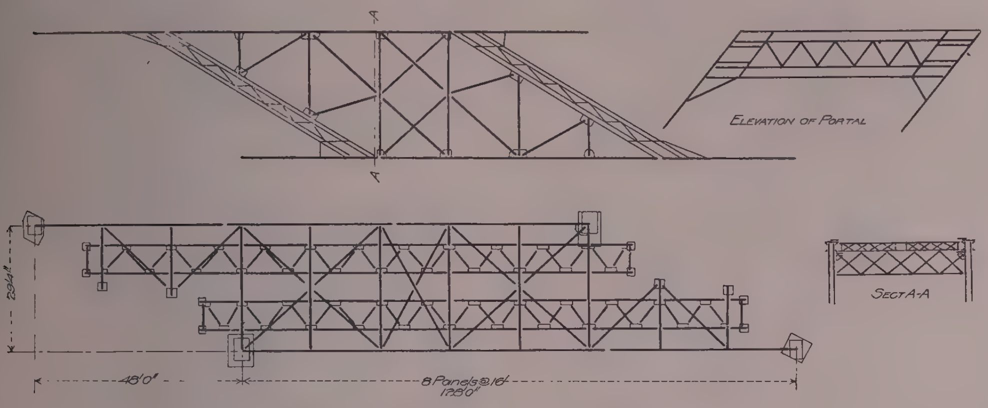
The bridge company erected the timber tower at the southeast corner of the bridge and then jacked up the old span 2 ft. 6 in., the railroad company raising the approaches at the same time. This was done on a Sunday, and the span was closely followed up with timbers and wedges to prevent accident and to allow trains to pass over with only delay enough to tighten up the wedges.

On the south side of the old span the bridge company extended the old floor beams by temporary cantilevers projecting about 7 ft. beyond the trusses. They then removed the north line of old track stringers and erected the new north truss 2 ft. 4 in. south of the old north truss and supported it by the old iron floorbeams, as shown on plan. They then erected the new south truss 4 ft. 2 in. outside of the old south truss. The top sections of the top laterals and struts were next erected; the old floor beams and stringers were replaced by the new ones, and the track was lowered to its proper position. The old trusses were taken down and the bottom sections of the new top laterals and struts were put in. The new truss span was jacked 3 ft. 3 in. north to its final position, and traffic was resumed on the double track.

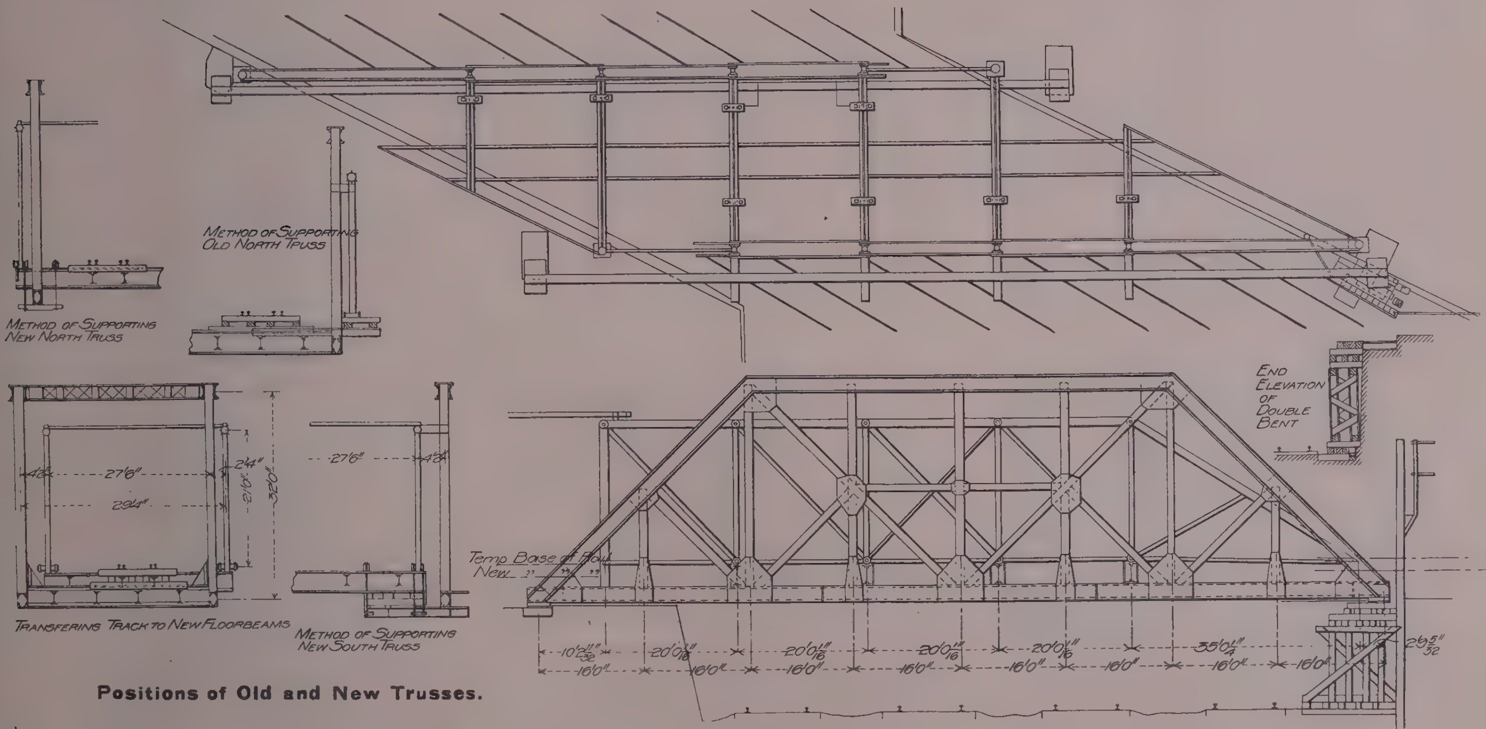
The new north truss erected inside the old north truss and 39 in. south of its final position, just inside the center line of the old north truss, was supported during erection by the floorbeams of the old span, from which 12 x 12-in. timbers 7½ ft. long were suspended parallel to the floorbeams and 2 ft. 3 in. clear of their lower flanges by means of U-bolts and vertical screw rods, as shown in the detail. The new riveted bottom-chord sections were assembled on these beams and supported the remaining members of the truss which were assembled to them and braced to the old truss as indicated in the general diagram.

The north and south trusses being assembled in their proper relative positions 29 ft. 4 in. apart on centers, the south truss cleared the old south truss outside of the old span, and its bottom chord was supported on the cantilever beams already mentioned, which were suspended from the old span by pairs of U-bolts engaging the old lower-chord pins and by vertical screw rods at the inner ends. The cantilevers were made of single 12 x 14-in. timbers 16 ft. long with a 12-in., 25-lb. reinforcement channel 9 ft. 8 in. long bolted to each vertical side. In order to avoid projections on the under side and keep the beams above the clearance line, these cantilevers were not suspended by yokes as for the north side, but were provided at the center with shelf angles riveted to the reinforcing chanels and having their horizontal flanges reinforced by vertical bearing angles and pierced with holes for the U-rods. At the inner ends, the upward reaction was provided for by blocking against the floorbeams. The vertical screw rods there were not required when the cantilevers were in action, but were provided for convenience in erecting the cantilevers and had shelf angles bolted to both sides to receive the lower ends of the rods.

The south truss was erected so far beyond its final position that the temporary position of the east end shoe came beyond the face of the abutment masonry and was supported, as already described, on a vertical falsework tower as close as possible to the face of the abutment and secured in position by a pair of ¾-in. horizontal guy ropes attached to the upper end of the tower and making a small angle with the abutment. One of them was anchored to a dead-man and another to an eye-bolt in the abutment masonry. The new trusses have riveted connections throughout, but at the end lower chord points Lo, Lo, etc., have pin bearings in riveted shoes seated on I-beam grillages which distribute their load on the pier masonry. When the span was moved transversely 39 in. to its final position the shoes slipped readily on the greased upper surfaces of the grillage beams, and the stringers, where they projected beyond the end floorbeams, were supported on transverse greased rails.



Lateral Bracing and Floor System.


Method of Supporting Old North Truss
Method of Supporting New North Truss
27'6"
29'4"
4'2"
2'4"
21'0"
32'0"
Transferring Track to New Floorbeams
Method of Supporting New South Truss
Temp Base of Rail
New
End Elevation of Double Bent
16'0"

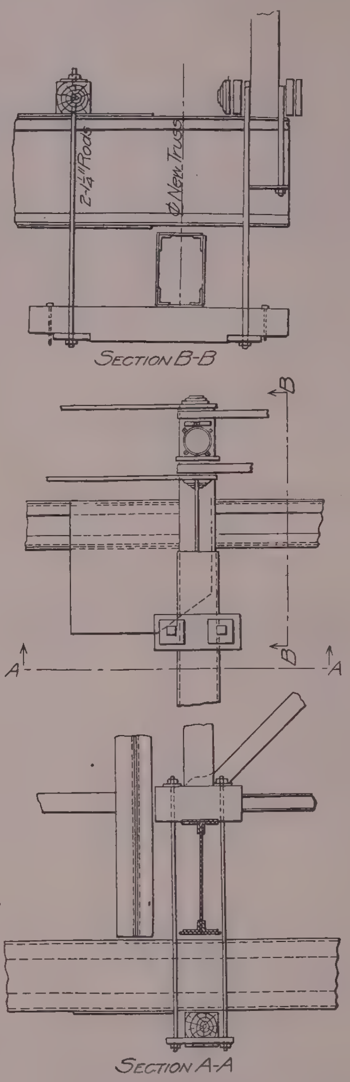
Positions of Old and New Trusses.

The old pin-connected trusses were not symmetrical, but had at the oblique angles of the skew a vertical end post; and at the opposite end of the truss, where the angle with the abutment was acute, the end posts were unusually long, were inclined at a comparatively small angle with the horizontal, and, with the lower-chord eyebars, were pin-connected to cast-iron pedestals. In order to raise the old span and provide additional clearance underneath it for the support of the new trusses, U-rods were paced on the projecting ends of the end lower chord pins and the nuts on the upper ends engaged transverse bearing plates on 12 x 12-in. horizontal transverse timbers 6 ft. long, which projected beyond both sides of the old truss far enough to receive under each end a 30-ton jack, and thus provide a harness by which the end of the truss was properly lifted. The vertical end posts of the old trusses were riveted direct to the floorbeams; they took bearing on horizontal base plates, without shoes or pin connections, and afforded no opportunity for engagement with jacks. A T-shaped vertical jacking piece 6 ft. 9 in. long was riveted up with a 15 x 1¾-in. web and two 4 x 3-in. flange angles. The web was made with two full-width plates 7-16-in. thick and two 11-in. filler plates, beyond which the outside plates projected to form jaws engaging the outside vertical flange of the end post. Fourteen rivets were cut out of this flange and were replaced by bolts securing the jacking piece to it. The horizontal lower end of the jacking piece was set about 3½ ft. above the top of the masonry, nearly in the plane of the top flange of the floorbeam, and a pair of 15-in. horizontal I-beams 7 ft. long were set parallel with the truss with their top flanges bearing on the girder. A 60-ton hydraulic jack was then set under each end of the beam and operated to lift the truss. Two other 15-ton jacks being also set in a line parallel with them on the opposite side of the end post engaged a wooden beam across the upper flange of the floorbeam. The free ends of the end floorbeams were also each provided with a 15-ton jack, so that the total number of fourteen jacks had a combined capacity of 450 tons. As the old span was lifted, the packing was followed up continuously by wedging until the required height was attained and the pedestals were supported on timber grillages seated on the masonry and provided with ¾-in. bearing plates on top. The grillages were made of solid double courses of crossed timber, each course being tied together with horizontal ¾-in. bolts and the upper course being secured to the lower one by ¾-in. dock spikes 2 ft. long. The end floorbeam was anchored to the east abutment by a vertical eye-bolt engaging its lower flange and adjustable by a steamboat ratchet engaging another eye-bolt drilled into the masonry.

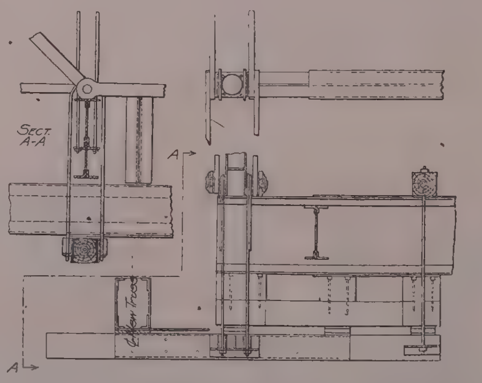
As the old north truss was outside of the new north truss, it was supported, while the old span was being removed, on bocking from ten 10 x 10-in. transverse cantilever beams 20 ft. long. These beams were fulcrumed on the new bottom chords, beyond which they projected about 5 ft. to receive a pair of 10 x 10-in. longitudinal stringers. Wedges were driven between them and the bottom chords, and the inner ends projected across the top flanges of two new stringers and were lashed to them to provide for the reaction.

Care was taken to locate the panel points of the new span so that the floorbeams would clear those of the old structure. As soon as they were erected, the track was blocked up on the new ties about 10 in. in the clear below the temporary position of the old ties, and the floorbeams and stringers of the old bridge were removed, commencing in the center of the span. The old floorbeams being suspended from the lower chord pins by U-bars were easily detached before the old trusses were disconnected.

The erection was done by means of a derrick and hoisting engine at each end of the bridge. The derrick at the east end of the bridge had an 80-ft. wooden mast and the derrick at the west end a 90-ft. steel mast. Both derricks had 80-ft. steel booms so located that they together commanded the whole span. The engines were each 30-h.-p., with two drums and four spools to each engine. The air compressor was located at the west end of the span and all field rivets were driven by pneumatic hammers. The new material was unloaded and stored at the west end of the bridge, and, as needed, was loaded by the west derrick on a small truck car running on the railroad tracks.



North Bottom Chord.



South Bottom Chord, Supportting Bottom Chords From Old Span.

The weight of the old span was	193,250 lb.
The weight of the new span, including steel grillages, is	594,000 lb.
The cost of repairs to masonry, including temporary interlocking plant and raising and lowering tracks, was	$11,300.00
The cost of new steel work erected, including inspection, engineering and superintendence, was	$28,200.00

The new steel work came together without a hitch and the method of erection was entirely successful. There was no serious delay to the Central R. R. trains and no delay to the Lehigh Valley R. R. trains.

The grillages were in position December 18, 1905. Erection of steel work was commenced March 12, 1906, and was finished May 16. During erection the bridge company's forces consisted of about 20 men.

The span was fabricated and erected by Lewis F. Shoemaker & Co., Philadelphia, Pa., Mr. J. H. Fichthorne, chief engineer, and Mr. L. D. Rights, contracting manager, who had special charge of the erection.

The work was designed and constructed under the direction of the engineering department of the Central R. R. of New Jersey, Mr. Joseph O. Osgood, chief engineer. The special features of the design and the details and methods of erection were worked out by Mr. Austin Lord Bowman, bridge engineer.

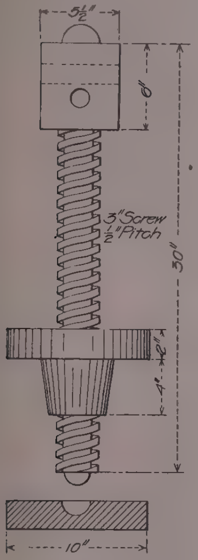
Draining the Everglades.

The drainage of the Everglades has lately been undertaken by the State Drainage Board of Florida, and the U. S. Department of Agriculture, having been asked to co-operate, is now making a preliminary investigation of the problem. The area is a swamp plain, 5,000 square miles in extent, reaching from the south shore of Lake Okeechobee to the south boundary of the State, and during the entire year is flooded with water to various depths. Saw grass of extraordinary length covers the plain, and there are scattered hillocks on which grow pine and palmetto, and subtropical bushes. The excess water must be removed and the annual rainfall of 60 in. must be provided for. In addition arrangements must be made to care for the overflow of Lake Okeechobee. It receives the drainage of about 5,000 square miles in the northern part of the State, and its only outlet, the Caloosahatchee River, is entirely inadequate. Besides the drainage problem, the agricultural value of the soil, the stability of drainage channels in this territory, the amount of shrinkage likely to take place where drainage is accomplished, and other problems are receiving attention. The preliminary examination includes the running of a line of levels from Fort Myers on the Gulf across the State to the Atlantic, thus tying the level of Lake Okeechobee with tide water. The State Drainage Board has already begun to dredge a channel from the head of New River at Fort Lauderdale on the east coast, northwesterly to the southern border of Lake Okeechobee.

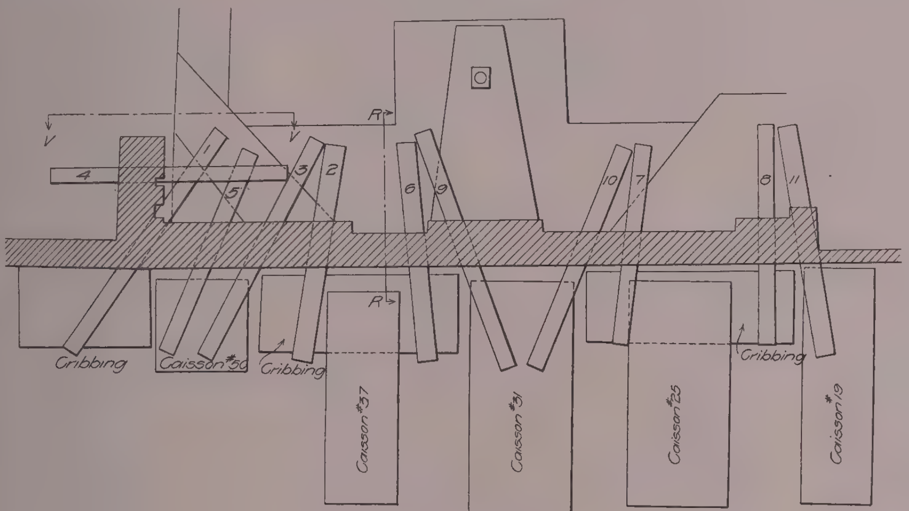
Subway Construction in New York along the proposed Broadway and Lexington Ave. route must probably either be done by tunneling or be subject to prolonged legal conflicts. A portion of the route passes the main fronts of some of the leading stores in New York, whose owners have begun to organize for opposing any system of construction other than tunneling. It is easy to sympathize with these merchants in their apprehension lest the streets be torn up, as was the case with the original subway construction, but nevertheless they are wrong in their judgment of the relative merits of tunneling and trench excavation as practiced on lower Broadway in New York and on Washington St. in Boston. Contractors have now acquired experience in trench work and can carry on construction with but trifling obstruction to traffic, while tunneling operations in fine running sand, such as is found in places along this proposed subway route, is almost certain to cause cracks and settlement in neighboring buildings not founded on bedrock or hardpan.

METHODS USED IN UNDERPINNING THE SINGER BUILDING, NEW YORK.

The twelve-story Singer Building, at the corner of Liberty St. and Broadway, New York, has massive brick walls carrying the outer ends of the floorbeams and girders. On the north side of the building about 50 ft. of the exterior wall is built close to the party line and is supported on a grillage of long 12-in., 40-lb. I-beams parallel with it. As the loading is eccentric from the center of gravity of the footing, an upper tier of 24-in. I-beams oblique to the plane of the wall are laid on the grillage beams with their outer ends spaced approximately equi-distant under the wall while their inner ends converge in two groups to receive the loads of interior columns, and in a third group carries the intersecting walls at the corner. This arrangement was made to distribute the pressure uniformly over the surface of the footing on the sand about 25 ft. below the Broadway curb.



Special Jack.



Underpinning Singer Building.

The extension now being built on the north side of the Singer Building has pneumatic caisson foundations sunk about 70 ft. lower to rock adjacent to this portion of the old building, and although great care is exercised in sinking the caissons, it was thought that the possibility of an inflow of quicksand or even the considerable drainage of water might undermine the old footings, and as its I-beams are parallel to the wall, a very slight disturbance of earth under them might become serious. It was therefore determined to support the wall temporarily on needlebeams until the caisson foundations were completed, after which the wall will be underpinned and the old footings jacked down if necessary to compensate for any settlement without displacement in the superstructure.

Operations were commenced by the excavation of a trench 4 ft. deep and 10 ft. wide for the full width of the building adjacent to the north wall. This excavation extended to the upper surface of the 24-in. top course of grillage beams which were found to be embedded in the concrete but not covered by it on their upper flanges. The bottom of the trench was covered with a single solid course of 12x12-in. timbers laid on the I-beams at an angle of 45 deg. with the wall so as to intersect as advantageously as possible the upper course of grillage beams and provide a platform to distribute the load from the timber cribs supporting the needlebeams.

At the northeast corner of the building the wall of the Broadway front forms a detached pier about 4 ft. wide, 6 ft. long and 140 ft. high, with an estimated load of about 500 tons. As it was uncertain what bearing the Broadway wall girders received in this pier, it was not deemed safe to pierce it for the transverse needles until some other support had been provided for it, therefore the needlebeam marked 1 in the general diagram was first inserted and jacked up to bearing without taking a very heavy load. A hole was then cut through the north wall and needlebeam 2 was inserted in it and jacked up to carry the full weight of the wall.

A hole 24 in. wide and 52 in. high was cut through the center of the pier 7 ft. above the bottom of the grillage for needlebeam No. 4. It was made by two men in about 24 hours by drilling about 120 2-in. holes with an Ingersoll-Sergeant steam drill and afterwards broaching out the honeycomb portion of the brickwork with a chisel inserted in the drill. Six 24-in., 80-lb. I-beams 27 ft. long, arranged in two tiers, were inserted in the hole and their ends were supported on cribbing as shown in the accompanying sketches. The east or Broadway ends are carried on six 40-ton and two 20-ton jack screws. The 40-ton screws are set 3 ft. apart in 12x14-in. transverse oak beams engaging the lower flanges of the bottom course of I-beams.

The 20-ton jacks are set in short 12x12-in. oak "pump logs" and their upper ends engage bearing pieces and fillers on the lower flanges of the beams. The 40-ton jacks are seated on a pair of 6x12-in. oak sills distributing their load over the cribbing built up with five solid 5x10-ft. courses of 12x12-in. yellow pine timbers laid on the diagonal timber covering the bottom of the trench. The 20-ton jacks are seated on short vertical posts resting on the diagonal floor timbers. Short 12x12-in. horizontal wedging timbers parallel to the needlebeams are placed between the jacks in the 40-ton end pairs and a transverse wedging timber is placed between the end and intermediate pairs of jacks.

The inner or west end of the No. 4 needlebeams was at first supported on the No. 1 needlebeam which consisted of eight 24-in., 80-lb. I-beams in two courses and was carried at the inner end by eight 60-ton jack screws in pairs with transverse oak cross-beams. The outer end of No. 1 needlebeam was carried on ten 40-ton jack screws and 6x10-ft. cribbing of three solid courses of 12x12-in. timber capped with I-beams. The bearing between the needlebeams and the wall masonry is made with 2-in. oak planks and a layer of cement mortar on top. The jack screws under the needles were successively screwed up one-quarter turn each by four men exerting their utmost strength on a 6-ft. capstan bar until the full weight of the wall was taken by the needles and it was lifted far enough to open a crack ¼ in. wide, which was subsequently increased to a maximum of about ½ in. wide as the jacking was repeated daily to compensate for the possible settlement. As fast as the jacks were screwed up pairs of oak wedges were driven tightly under the filler blocks to follow up the movement and avoid any possibility of drop in case of accident to the jack screws.

Finally, a group of four 60-ton jacks were placed under the inner extremity of needle 4, and set up to take part of its load, enabling needle No. 5 to be removed. This left the entire weight of the pier supported by needles 1 and 4 until it was convenient to complete the underpinning and transfer the pier load to it. While a portion of the wall was supported on needles 2, 6, 7 and 8, carried at their north ends on cribs occupying the future positions of caissons 37 and 25, the intermediate caissons, 50, 31 and 19, were sunk and any tendency to settlement of the wall that may have been caused by their excavation was provided for by the needles. As soon as the piers were completed on these caissons additional needles 3, 9, 10 and 11 were inserted close to the first set of needles in directions oblique to the wall so that their outer ends rested on the piers. Needles 2, 6, 7 and 8 and the cribs supporting their north ends were then removed and the remaining caissons 37 and 25 were sunk, settlements being safeguarded as before by the needles. This method left maximum distances of 15 ft. between needles on the center line of the wall, but as the masonry was very strong and sound and the continuous support under its footings was not wholly removed, the stability was maintained without any displacement, extreme stress or apparent injury.

Each needle consisted of six 24-in. I-beams from 20 to 27 ft. long in two tiers supported at each end on six 40-ton jack screws and carrying an estimated load of about 130 tons. The jack screws, like those described for needle 4, were seated in transverse oak beams and a transverse blocking timber was provided under the end of the needles close to the jack screws and wedged up as fast as the jacks were operated. The cribs supporting the inner ends of the needles were 10 ft. wide and 13 ft. long, parallel with the wall, so that each supported the ends of two needles. They were made with three solid courses of 12x12-in. timber and two solid courses of 3x12-in. planks on top. The cribs for the outer ends of these needles were located in the spaces afterwards occupied by the ends of the caissons and each of them was also made 10 ft. wide and 13 ft. long, to take the ends of two needles. Each was composed of three solid courses of 12x12-in. timbers laid in a pit excavated to a depth of 23 ft. below the curb, or about 1 ft. above water level. The upper course of timber was capped with a grillage of fifteen 15-in. I-beams 13 ft. long, on which were laid twelve 6x12-in. oak timbers 10 ft. long to receive the jacks.

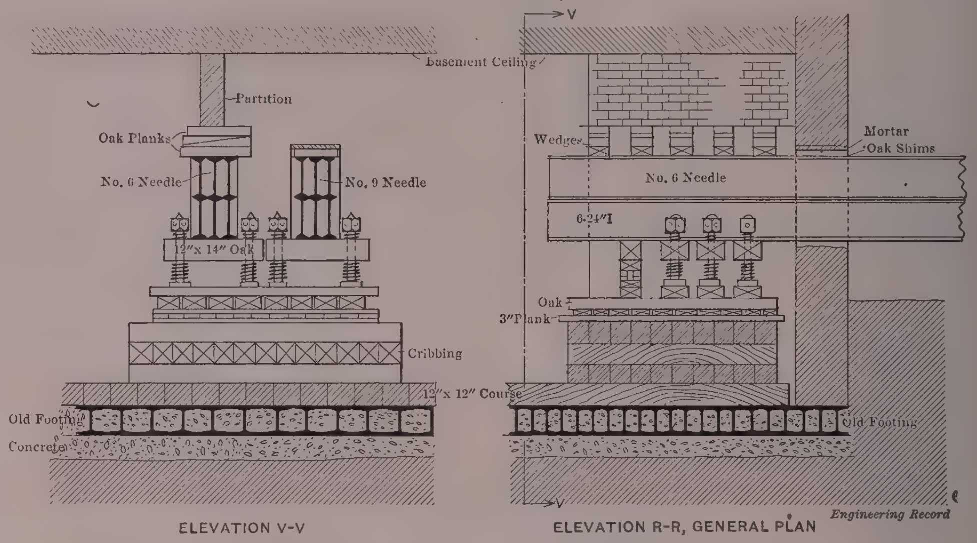
The connection between the wall and the underpinning is made in the usual way with heavy pairs of dressed granite blocks separated by pairs of 3-in. steel wedges 18 in. long tapered from nothing to ⅝ in. in thickness. In order to prevent the spawling which often occurs on the edges of the wedging stones, the wedges were set between pairs of 1-in. plates 6 in. wide and 24 in. long, transverse to the wall. These plates were bedded in cement mortar and the upper plates were covered by a piece of burlap on which the mortar was spread, thus preventing it from penetrating the space between the plates. A little sand was spread between the plates to separate them about 1/16 in. at first and allow the wedges to be entered from opposite sides. They were started singly and engaged each other about the center of the plate. They were driven to practical refusal and the ends cut off square with hack-saws and the spaces between them grouted in the usual manner. The underpinning of the wall beyond the pier was accomplished with three needles in simultaneous operation which were twice replaced, making nine different needling operations.

The 60-ton jack screws used were of special construction made from solid forgings 3 in. in diameter with square threads of ½-in. pitch. Both top and bottom are provided with hardened hemispherical bearings and on the top is forged a 5½-in. capstain head 6 in. long. The screw engaged a circular cast-steel nut 10 in. in diameter and 6 in. long made with a flange pressing against the face of the oak block and a tapered body fitting the hole bored in the block. The 40-ton jacks were similar except that they were made of cast steel and were 4 in. in diameter with a 2-in. hole cored through the center.

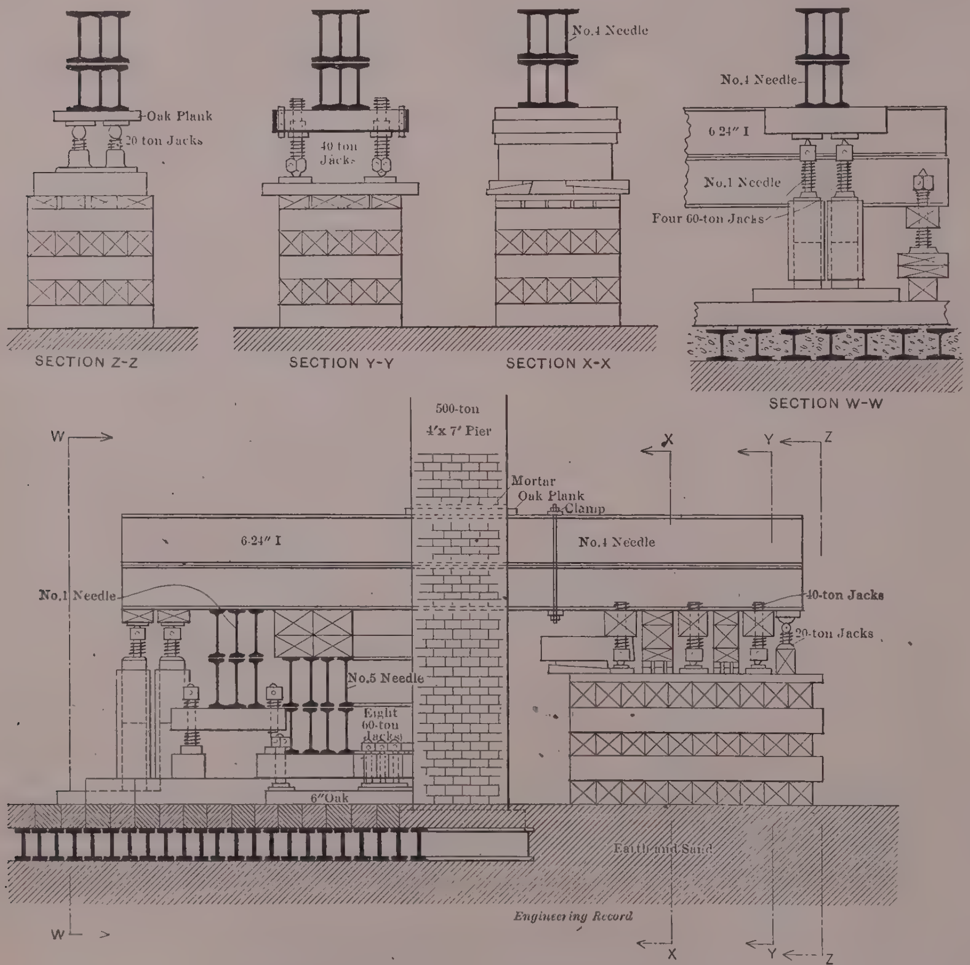
The work here described was commenced Sept. 4, and the last needle was set Dec. 15. The plant employed included forty-four 24-in., 80-lb. I-beams from 20 to 27 ft. long, two 20-ton, six 40-ton, and seventy 60-ton jacks, part of them from stock and part of them made specially by the Union Iron Works. There was also used about 25,000 ft. board measure, of timber blocking mostly in 12x12-in. sizes and 10 to 13-ft. lengths. The I-beams were handled entirely from the outside by derricks except those in needle-beam No. 4, which were brought into the cellar of the Singer Building by rolling and skidding.

After the blocks and jacks had been set in position, the different groups of needles were placed and the wall loads transferred to them in an average time of about eight hours.

The work was executed by the Foundation Company, the general contractors for the substructure of the new Singer Building, under the direction of Mr. Alexander Allaire, superintendent, and Mr. C. T. Nickerson.



Intermediate Needles Under Side Wall.



Needle Beams and Cribbing Under Corner Pier.

The Largest Suction Producer Gas Plant in the United States is said to be that of the Fairbanks-Morse Mfg. Co., at Beloit, Wis. It consists of six 150-h.p. producer gas engines, five of which are belted to electric generators, and the sixth to a two-stage Ingersoll-Rand air compressor. The company is now planning to add to this installation three 200-h.p. producer engines.

Proposed Law to License Surveyors in Minnesota.

Licenses for civil engineers are proposed in a bill introduced in the Minnesota House of Representatives, a few days ago. The bill provides for a State Board of Surveyors, each of whom shall serve for four years and must have at least ten years' experience. Any surveyor in the State may file an application for examination by paying a small fee to the secretary of the commission. In addition to passing the examination he must also show that he has been a graduate of some reputable engineering school and has had one year's experience, or else has had five years' experience as a surveyor or an assistant in charge of a surveying party. The bill provides that after this year it shall be unlawful for any register of deeds to record any plat or survey of land, lines or division of land unless it has been approved by a licensed surveyor or is agreed to by all parties concerned. All plats and surveys of roads, ditches and other public grounds, after the close of this year, can be made only by a licensed surveyer. It will be noticed that this proposed law agrees to some extent with the law of Canada, under which the surveyors of the Dominion are required to pass an examination and take out a license before they can carry on their work.

A Very Large Compressed Air Plant has been installed in the enlarged foundry of the General Electric Co., at Schenectady, N. Y., and air is now used in nearly every operation connected with the making of a finished casting. Throughout the company's mammoth plant electric power is used to run the machinery either by direct application to each machine or to a line shaft. In the foundry, however, where operations are scattered and intermittent, compressed air was found advantageous for small power services. The air at 80-lb. pressure is supplied by a motor-driven compressor having a capacity of 1,700 cu. ft. per minute. The compressor is driven by a 225-h.-p. motor. Among the machines using compressed air are the following: Tabor molding machines, core oven cars, jib cranes, heating and ventilating fans, sand blast apparatus, chipping tools for cleaning castings, and the cupola blowers. Some idea of the extent of the installation can be gathered from the size of the foundry. The building measures 140 x 880 ft., with a wing 120 x 170 ft., and has a floor space of 214,000 sq. ft. The flask storage yard measure 50 x 450 ft. There are five cupolas, 45,000 castings, weighing 550 tons, are produced per week, and 1,030 men are employed.

HINTS ON THE DESIGN AND EXECUTION OF REINFORCED CONCRETE WORKS.

By E. P. Goodrich, M. Am. Soc. C. E., Consulting Engineer, New York.

The following items concerning concrete work in general and reinforced concrete building work in particular, are taken from a note-book which the writer habitually carries and in which he enters as they formulate themselves, the results of his experience, and his observations of the methods used and work done by others. None of them may be new to some, some may be new to none, but it is hoped many may be of assistance to many. The classification is only suggestive:

To Prospective Builders.

Reinforced concrete has many advantages and many disadvantages. It can be a successful competitor of timber or of brick and steel only under certain conditions—not invariably.

Concrete buildings are practically the same in cost as similar ones of steel frame construction up to about six stores in height in most parts of the United States. Often, conditions make it possible to build in concrete such low buildings for a small percentage less than in steel. For buildings over about six stories conditions must be very favorable to make concrete the more economical. Usually a composite design can be secured with many of the advantages of concrete and at a nearly minimum figure.

For warehouses and manufacturing buildings, concrete is as reasonable as timber in first cost, unless the latter is comparatively cheap. Late bids on ten and more story loft and office buildings in New York City were approximately 10 per cent. higher for concrete than bids for steel frame buildings received at the same time. On the other hand, bids for manufacturing buildings six stories high were the same percentage lower for concrete than for steel frames. First costs for mill construction warehouses up to eight stories in height were slightly less than for similar buildings of concrete. One-story structures can be erected with flat concrete roofs under favorable circumstances as cheaply as in timber, unless the latter may be of open joist construction.

In more rural districts where metropolitan laws and prices do not hold, conditions are almost invariably more favorable to concrete. In one instance bids for concrete manufacturing buildings were actually secured at 50 per cent. of those for timber. However, the actual construction costs were not as favorable as this, and any such discrepancy should be carefully investigated.

Concrete cottages and larger dwellings have been erected as cheaply as were adjoining ones of timber and of timber and masonry. For such relative costs, conditions must be favorable, however, such as having sand and gravel on the premises, ability to carry on work economically at slow rate so as to make repeated use of centering materials, etc. Under such conditions, concrete can always compete successfully with timber and even with steel frame structure.

In general, little can be saved by building in concrete, except in liability of loss by fire and its attendant inconveniences, delays, etc.

During times of congested market conditions, concrete buildings can often be completed before similar ones of timber or steel could be erected, because the materials needed for concrete work can usually be secured much more promptly than can structural steel or heavy timber at reasonable cost.

The lowest insurance rates in the country are found on some concrete warehouses and factories with sprinkler equipment to protect contents. It is cheapest in the long run to get the most experienced engineer to design the structural part of the buildings and supervise their erection. An engineer who is not affiliated with any company commercially exploiting any special type of bar, form of reinforcement, or method of construction is less likely to be biased in judgment than those with special affiliations.

If bids are received on miscellaneous designs and types of construction, such an independent engineer of experience should carefully compare designs before contract is awarded. Get the contractor with the most experienced organization to do the work, irrespective of price, charging the difference in estimated cost to accident insurance, if thought desirable. Get the architect who has had the most experience in concrete work, to design the exterior of the buildings, if special artistic effects are desired. Get the architect into the spirit of the material employed, and exact a design appropriate to concrete. If he insists on copying effects characteristic of brick, wood or stone, change either the material employed or the architect.

On the other hand, unless the building is of absolutely the least importance as to appearance, don't expect to be contented with the concrete surfaces just as they come from the forms. Even the least important should have the interior surfaces pointed and painted, and the exterior ones pointed and grouted.

Don't expect to get moisture-proof walls unless special precautions are exacted, with their corresponding extra costs.

No engineer, architect or contractor who knows his business will guarantee a building against cracking. The use of ample reinforcement, properly placed, and the construction of work during cold weather with proper precautions as to joints, will almost entirely obviate cracking. Expect some cracks and be thankful if accident or extra competence on the part of the engineer and contractor hide such defects.

Concrete is not necessarily damaged by freezing. Some of the best work ever erected has been done when the temperature was ten to twenty degrees below freezing.

Concrete buildings are not colder or damper than brick ones. Concrete warehouses have been occupied without damage to exceedingly sensitive merchandise, within a week after the forms were removed. In one instance this occupation took place story by story as the work was completed.

Be very chary of concrete building brick or concrete blocks unless the mixture used in their manufacture is identical with what would be used if the walls were monolithic.

Of course bids may be secured on designs, each prepared by a separate bidder, but a much better method is to have a design prepared by an expert on which all can bid, each bidder adapting his special methods to the design prepared and all estimating on exactly on the same quantities of concrete, steel, etc.

Do not blame the architect or engineer if the bids received do not tally to a penny with estimates previously made, especially if several months intervene between date of estimate and that of letting contract. The more experienced the estimator, the closer the estimate. Every experienced contractor allows a wide margin for contingencies in preparing estimates, especially where labor conditions are uncertain and where experienced and competent labor is not plentiful.

To Architects.

Field of Usefulness.—Concrete has a unique and proper field. It cannot and should not be forced to compete with steel, timber or masonry under all conditions. Do not think it necessary or try to make concrete imitate other materials, either as to finish or as to structural design.

The value of concrete in the construction of warehouses and factory buildings of moderate height is unquestioned. Where fire prevention is important it finds its greatest usefulness.

Where bold or simple exterior treatment is appropriate, concrete can be employed to advantage.

Styles of Architecture and Surface Finish.—Use the Mission style of architecture, or other simple massive type, rather than the elaborate classic orders.

Don't try to imitate brick or stone by devices of centering. Let the architectural details show that the material is concrete and let it stand for itself.

Secure contrasts by means of shadows, by using deep reveals at apertures, and heavy (but not heavily overhanging) cornices and belt courses.

Simple balconies with strong supports may be exceedingly effective if relieved with ornamental iron railings or awnings of appropriate design. If iron is used it must be galvanized or constantly painted. Don't try to exact numerous sharp projecting edges or moldings. Instead, design them with sweeping curves and beads.

In designing horizontal moldings, do not employ level top-surfaces for projections. Remember that the concrete must flow on a slight down grade to reach all points, and that air is readily pocketed unless surfaces are so sloped that it is easily driven out. Thus, horizontal surfaces should almost never be employed in moldings. Proper bevels also assist in easy removal of forms.

Very effective and easily constructed ornamentation can be secured in the form of intaglio work. Greek frets are easily worked out on the forms and are often very effective.

Relief work can be applied in stucco or cement mortar if proper metal bonds are provided and the original surface is carefully prepared to secure a good bond. Obviously, such work should preferably not be very heavy, although with proper care very heavy masses can be satisfactorily employed. The best method of securing intricate detail is to have the ornament cast separately and fastened in place in specially provided slots or set as the work proceeds. In either case ample reinforcement, both in the cast ornament and for securing same in the work, should be employed.

On the other extreme, do not expect to be able to obtain large expanses of plain wall or long lines of pilasters or cornices without slight waviness, if built in mass concrete. Such work can be secured, if necessary, but it is costly, requiring extra heavy forms and excessive care during the deposit of concrete. Break up such areas and long lines by proper devices. Neither expect to secure such large areas or long lines without some cracks. Such defects can be obviated almost entirely by good workmanship and use of sufficient and properly disposed reinforcement, but it is also wise so to design as to provide artificial joints along which cracking will take place, if at all, and where it will be entirely concealed.

If the practically uniform gray color of cement is objectionable, its tone may be modified by applications to the surface, by artificial treatment of the surface, or by introducing coloring substances among the concrete ingredients.

Except for the crudest work, all concrete surfaces should be treated. The ordinary paints, especially of the cold water variety, are not satisfactory. Even cement grout unless carefully applied will prove deficient. One or two special preparations, however, have proved of value.

Stucco can be employed where special finish is required. Key joints should be formed in the body concrete and heavy reinforcement installed where stucco is more than an inch in thickness.

Wire lath of every variety, even when carefully coated with preservatives or galvanized, has shown itself liable to disintegration when used as a frame for stucco cornices, etc.

Coloring matter can be introduced into the stucco if desired, but most coloring substances are bleached by the cement and are of short life.

Colored brick, tile, or terra cotta, if of heavy design and considerable thickness, can be imbedded in the concrete work as it is carried on, if the concrete is rather dry in texture and if care is exercised in the proper placing of the ornamental blocks. In such work, joints must be formed and maintained uniform by the use of proper wooden wedges and strips.

Tile can be employed if it is first glued to perforated forms with common bill posters' paste. When concrete is properly set, deluging the forms with water will dissolve the paste so as to allow the removal of the molds. Copper tacks can be used to secure tile to centering and no discoloration from rust will take place after the removal of the forms.

The impress that is left by the forms can be removed from old concrete best by mechanical treatment of the surface. Fine picking, chiseling, or hammering either by hand or by pneumatic tools will produce differing effects according to circumstances. Sand blasting has also been successfully employed.

With mortar, sandstone can be imitated.

With granite screenings, work closely imitating cut granite can be secured.

With large pieces of stone, less effective results can be secured and gravel concrete does not lend itself very well to such treatment.

Treatment with acid, afterward carefully neutralized and the surface washed, will give most effective results. Gravel can then be used to excellent advantage.

Where forms can be removed as soon as the concrete is self-supporting, simple flushing of the surface with water and more or less scrubbing with corn or wire brushes will remove the cement mortar so as to expose the aggregate in an effective manner.

If a mortar surface is desired, simple floating with wooden floats while applying a grout of sand and cement gives fair results.

Combinations of concrete columns and common brick or terra-cotta window panels give strong contrasts.

Concrete brick or concrete blocks lessen this contrast and can be adapted to many ideas of treatment.

Bronze, copper or painted pressed metal, can, of course, be employed to any extent to give color and ornamentation.

Blocks of mortar or concrete made with very fine stone can be planed, sawed or turned with machines, just as the softer quarried stones are handled, producing almost perfect stone imitations.

Brick or stone can, of course, be used as a veneer for structural concrete work, but such combinations are much more costly than simpler methods.

Well planed, selected lumber, in narrow pieces of good thickness and tongued and grooved, gives the best finish for surface work which is not to be specially treated; but even with the greatest of care, dust will soon become attached to the surface, and in such a way as to reveal the joints between boards and all other blemishes.

Construction Points.—If all concrete surfaces are to be plastered or stuccoed, terra cotta or plaster block will usually be found cheaper for partitions, curtain walls, etc., than concrete.

Common brick or concrete blocks for thin walls are also less expensive than mass concrete work where an equal thickness of concrete is exacted by building or other regulations.

Don't try to employ concrete where structural steel would be cheaper, as in shallow beams or those of very long span. Very often a timber or steel frame roof is less expensive than a concrete one. Structural steel or cast iron columns can be combined with concrete floors with excellent results and should be employed where tall or small columns are necessary.

Plan floor openings so as to allow an economical arrangement of forms and of reinforcement details. It will often be found most economical to carry columns of one size from bottom to top story to save changing column forms. Design columns with some sort of cap. This allows of an economical design of forms.

Expansion joints in concrete buildings are usually unnecessary, and as usually installed are absolutely worthless.

Use bevels or fillets on all corners.

Protect corners of partitions and columns with metal facings, especially in factories and warehouses where heavy merchandise is moved on trucks.

Do not use brackets or kneebraces under ends of beams and girders unless absolutely indispensable. The cost of the necessary forms will be relatively large and more than enough to offset extra steel or concrete properly disposed.

Plaster or stucco will stick better to concrete deposited in a dry than in a wet state. The coarser the sand in the aggregate, the better the surface for stucco.

Determine, before work commences, the exact location of all floor openings for pipes, outlet boxes, etc. Some cutting will be inevitable, but great care should be exercised to provide against it as far as possible, since it is more expensive in concrete floors than in any other variety.

Double concrete walls, even as thin as eight inches total, can be erected by special devices almost as cheaply as solid concrete ones of equal total thickness. Such walls do not require the furring which should be installed in all solid concrete dwelling walls.

To Structural Designers.

Reinforcement.—Don't try to design your reinforcement with closer economies than can be secured in purchasing the material. Steel mills exact a variation of five per cent. Do not forget that concrete is practically monolithic, and design accordingly. Use as much steel to resist reverse moments over supports as is used for regular spans.

Use relatively large percentages of reinforcement; i. e., 1 per cent. or more. It is more economical. Tests show that the concrete is better stressed and the work is better tied together. Cracking is less likely and reinforcement does not get readily displaced.

Use plenty of stirrups. Space them closer together than half the depth of the beam or girder, if any are used at all. From a practical standpoint, vertical stirrups are as good as diagonal ones.

Use reinforcement fabricated in units as far as possible. It does not get displaced, it is more economically handled, it is more cheaply fabricated, and it is more readily inspected.

Do not try to make reinforcement rods so long as to extend over more than one bay, unless the rods are absolutely straight. Reduce to a minimum the number of bends in each rod and the number of types of bent rods required on each job.

Reduce to a minimum the number of different types of reinforcing units on each job.

Carry stirrups well into each "flange" of each beam. The inverted U-shape gives lateral support to the compression side of beams and secures ample anchorage for each stirrup. Fasten stirrups to tension bars in some secure way. Wrapping is good; rigid attachment better, but not imperative, and much more costly.

Use any pattern of rod and of any elastic limit, as found most convenient. Plain round rods give better results per unit cost than any other, under most conditions. High elastic limit rods are of no more value than low limit ones in preventing the first crack.

If stirrups are not wrapped or rigidly connected to tension rods and if they are not bent or locked at tops, be sure there is plenty of adhesion developed to bring them into the action for which they were intended. Simple dependence on a short length of a patent bar designed to increase adhesion is dangerous. Either use long pieces or, better, provide ample hooks or threads and nuts with bearing plates, or turn the ends around lateral rods and wrap them securely with wire. The connection between the face or base of a retaining wall and the counterforts is a case in point.

Long bends are best in main reinforcing rods (if same are bent), except at ends. Stirrups can have short bends.

If stirrups are wrapped around main rods, this work can be done cold if the stirrups are of small diameter and if units are fabricated at the side of the job.

If much handling is necessary before reinforcement is finally placed, the wrapping can be done hot to better advantage, thereby shrinking the stirrup slightly against the main rods.

Stirrups are particularly necessary in reinforced footings, which are constantly saturated. They are also imperative in members subject to constant changes of load. At the ends of beams horizontal rods are practically worthless to resist shear.

Be careful about getting excessive bearing stress between concrete and steel reinforcement, especially near supports.

For slab reinforcement, use rods in as long lengths as possible. Use reinforcement in two directions in all slabs possible, but remember that the supporting power of such steel varies approximately as the fourth power of the various spans.

For work where adhesion is important, use numerous rods of small diameters. Otherwise use as large diameters as it is possible to employ. They are cheaper to buy, to bend, and to place.

At corners, use ample steel to tie together joining walls.

Carefully reinforce ornamental or other blocks cast on the ground which have to be set in recesses left for the purpose.

Employ reinforcing rods to produce continuous action in beams wherever it is possible for such action to occur. Use ample steel, because if cracks start, they are sure to increase under variations of load.

Use ample reinforcement in belt courses, cornices, etc., to connect them to main walls. In general, more reinforcement is needed to prevent cracking at changes of thickness than in main walls. In columns, arrange the reinforcement so as to support concrete laterally as much as possible. Above all, arrange the reinforcement in columns so that concrete can be readily deposited and easily and absolutely compacted throughout the whole mass. Arrange reinforcement so that columns can be absolutely cleaned of rubbish of all kinds. If heavy vertical reinforcement is employed, see that proper metal footings are designed in foundations, under each vertical reinforcing member. Where joints occur between abutting vertical reinforcing pieces, see that the connections will develop the full theoretical strength of parts. It is best to make splices at floor levels, where beams and slabs give lateral support. Where changes of size occur in columns, and rod spacing changes correspondingly, use heavy ties and other connections to prevent buckling of vertical reinforcement under load.

Be particularly careful about arrangement of reinforcement where beams and girders meet columns. Often there is little room for any concrete. If reinforcement in sheets is employed be careful to make ample laps and bring them over supports.

General Design.—Do not use factors of 2½ for steel, 4 or 5 for compression in concrete and hardly more than one for so-called shear in concrete. Be consistent in assumptions.

In engine beds, column footings, etc., the old style, unreinforced design, which has proved eminently satisfactory in the past, is often cheaper than the new style of reinforced work.

Study designs of details of connections between members more carefully than they would be examined if in structural steel. In this connection do not forget effects due to shrinkage in setting. Columns have been observed which have shrunk one-half inch in twelve feet. All designs of reinforcement, whether in beams, girders, foundations, etc., but especially in columns, should be made with this inevitable shrinkage in view.

Expansion and contraction, due to temperature changes, in roofs is a vital factor.

Remember that concrete has a very low shearing value (as usually designated), especially at early ages. It has practically no tensile strength at those periods.

Do not forget that centering is often removed long before it should be in view of the current methods of design.

If different allowable maximum unit compressive stresses are assigned to different grades of concrete, it will usually be found most economical to use the grade throughout which contains the most cement, provided areas can be proportioned in strict accord with assumed stresses.

Where work is not likely to be inspected during construction or where it is possible that inexperienced contractors may undertake to carry out the work, make details of the simplest possible design and employ exceedingly conservative unit stresses.

Where it is known beforehand that proper supervision and experience will enter the work, from 10 to 25 per cent. may be saved in materials. This is the price of assured experience and care. No measure can be placed on insurance against the possibility of finding sawdust, shavings, or batches of concrete containing no cement in columns, when the forms are removed.

Do not expect slabs to give effective support to the compression sides of girders unless the slab and the stem of the T-girder are placed at one operation. Neither depend upon its effectiveness, unless the slab is of good thickness and well connected to the stem by properly designed reinforcement.

Where wall or other girders are designed so that the load is carried by the lower edge (as where floors are carried by girders under windows) use stumps on equivalent means of tying together the tension and compression sides of girders. Chances are almost infinite against the whole girder being deposited without a plane of natural cleavage at the level of the top of the slab.

Reduce to a minimum the number of different sizes of beams and girders in a building. It often happens that the roof construction can be more economically made the same as the lower floors as to carpentry and concrete, than to remake all the forms and thus save a small amount of concrete.

Be careful to bond curtain walls to columns or adjoining walls, if all are deposited at one operation or if cracking is objectionable in the curtain walls. A much better method is first to build warm walls or columns with slots or recesses the full widths of curtain walls. The latter will then have an opportunity to shrink, contract and expand, etc., without cracking either in its own mass or where it joins the column or main wall.

In designing columns, remember that most of them are loaded eccentrically. Remember, too, that the dead load which they carry is apt to be a large proportion of the maximum total, when the unit floor loads are light.

Design beams and girders so that forms may be readily removed. Give the sides as much batter as possible.

Do not expect wall beams and girders to act independently as such, if they are deposited at the same time as the curtain walls either over or under them.

Remember that as usually designed, little reverse moment anchorage can be secured where beams enter walls, except by twisting wall girders.

Concrete piles can be built so as to be readily driven with an ordinary pile driving machine, if of heavy construction, and if equipped with a heavy hammer. The heavier the hammer the better. In such piles, use just enough longitudinal reinforcement to assure the lifting of the pile without breaking. Use ample spirals or bands, especially near the head and the point. Often concrete pile foundations will be found cheaper than wooden ones, where the permanent water level is very deep. Concrete pile foundations may also be cheaper than mass concrete ones where the top layer of soil is poor. Sometimes, however, under such circumstances large footings of poor grade concrete may be more economical, or largely spread reinforced footings.

There is no reason why a concrete pile should be allowed more load than a wooden pile of the same diameter where the sole dependence for supporting power is placed on the frictional resistance of the earth. The usual pile formulas are inapplicable to concrete piles. When the concrete piles are used in work in which beams are afterward to be attached to them, special means must be employed to secure proper connections. Otherwise, costly cutting will be necessary.

Brick curtain or bearing walls can usually be run up as rapidly and cheaply along with the concrete floors as the work can be done after the floors are in place. If brick walls are run a story in advance, as in a timber building, the brickwork can be so designed as to take the place of wooden centering in large part for wall columns and wall beams.

TO SUPERVISING ENGINEERS AND INSPECTORS.

Test *all* cement. Best have it done at the mill, before shipment, by an expert who will certify as to results, watch loading and seal cars with special seals. If this is not practicable, at least make pats and boiling tests at the work. Have cement delivered as far ahead of time as possible, and make the contractor use the oldest at all times.

Test all sand. Best find relative quantities of different sizes by standard method and correct deficiencies by purchase of special material. If this is not practicable, at least, frequently shake samples in water in a slender bottle or large test tube and allow it to settle quietly, so as to approximate the amount of silt present. If this silt does not exceed 10 per cent. of the whole mass, and is not vegetable mold, the sand may be used. It should preferably consist of less silt and of a combination of all sizes—not all fine or all coarse.

If there is doubt as to the quality of water available, have it tested in a practical way by experts. Water taken from streams into which manufacturing wastes are dumped should be carefully examined. If sewage sludge is present, it is apt to coat the stone or gravel and prevent proper adhesion between it and the cement. Sea water is entirely satisfactory unless contaminated with sewage or manufacturing wastes, as is the condition in many harbors on our coasts.

Some engineers advocate the use of salt in fresh water during the whole year. The salt retards the rate of setting and also lowers the freezing point of water. In winter the latter property is of material use, while cement sometimes sets too rapidly in hot weather and the additional salt is of value.

Test all gravel and broken stone. See that stone particles are all cleanly broken and have no incipient fractures. The harder and tougher the quality of the rock, the less the danger of this defect. See that gravel is not coated with silt. Have it washed if necessary to secure clean material. See that all aggregate consists of particles of variable size from those of the size of the largest sand to the largest stones. For good cinder concrete work, it is often necessary to screen out the ashes and refuse, and often to crush the large clinkers.

Determine the proper proportions of sand and stone or gravel by finding what mixture has the maximum weight for a given volume. To do this, use a common galvanized iron pail and a spring balance. Mix several batches of differing proportions, using full pails of material in each instance. Small batches are apt to prove deceptive. Don't mix in a conical pile, so that the large stone rolls away and is either ignored or taken in excess. Instead, use a flat bed. Do not ram into the pail. It is almost impossible to ram twice alike. Instead, fill the pail about half full of water and sprinkle sand and stone into it slowly from a shovel. Fill the pail level full in each instance, allowing the excess of water to run over the edge.

The combination of proportions having maximum weight should be used for all classes of concrete. For poorer mixtures use less cement. To determine best proportion of cement, use the predetermined combination of sand and stone and mix different batches with varying proportions of cement. The concrete thus produced should be mixed rather wet and be well puddled into the pail until it is level full. The combination giving the greatest weight is the ideal one, but more or less cement may be found advisable under various circumstances. If impervious concrete is desired, more cement must be used in each batch. If poorer grades are admissible, less cement may be employed in the regular batch. Small variation in proportions of all the ingredients from the maximum will be found to make little difference in the resulting weights.

On jobs of relatively small aggregate cost, it is best to specify clearly the exact conditions with which the contractor is to comply, the exact quantities and proportions of material to be used and how they are to be mixed and deposited. Such work most often falls into the hands of inexperienced or low-grade contractors. For such contractors a lump sum contract, with no opportunity for variation from the specifications, is best.

On large work, however, more discretion can and should be given the contractor and the supervising engineers and inspectors. In such work, specifications should be so drawn as to afford this latitude, and the contract should be of the percentage, fixed fee, unit price, premium, or other modified form.

Where at all practicable, do not specify two or more grades of concrete for simultaneous use, such as a rich mixture for columns and a poorer one for floors. It is almost inevitable that the two varieties will become confused and be wrongly deposited unless excessively and exceptionally rigid inspection is secured. If deemed wise to use different grades of material, make them so different as to be readily distinguishable. Put some lamp black into one, or use a different kind or grade of aggregate.

For concrete to be used between railroad ties or floor sleepers, or on poor ground for light foundations, for mass filling, for mattresses, etc., poor quality aggregate may be employed economically. Cinders (really ashes), slag, poor quality stone, broken brick, old concrete, etc., will be found serviceable.

In joining new work to old, see that old work is saturated with water before new concrete is deposited. A coat of cement grout over old work or a first batch of mortar is a wise precaution, although not half as valuable as the use of plenty of water on old work.

Always require that columns, walls and other deep masses be given a chance to attain preliminary shrinkage before depositing adjacent shallow masses like floor slabs, beams, etc. Columns have been observed which have shrunk one-half inch in twelve feet.

Be especially careful that lumps of frozen sand or stone do not get into the mixture in freezing weather. Even with the use of boiling water, such lumps are often not thawed out, and they may form a considerable pocket of uncemented material in the finished work. In a small column this might be disastrous.

Do not allow concrete to be deposited in large masses (as from large buckets) except under the most favorable circumstances. Masses of entrapped water, and even air, have been found to have formed large voids in the concrete work.

Take great care that concrete is carefully deposited in columns at floor levels where reinforcement from columns, beams and girders meet. See that no voids are left under rods and that good quality material gets into the work. Better use a special batch of specially rich mixture at each such point.

In using concrete piles in which the concrete is deposited in a hole in the ground, be absolutely certain that freshly deposited or unset concrete is not disturbed by driving for other piles in the vicinity, in such a way as perceptibly to compress and move the earth. See that concrete is deposited with the greatest care for all concrete piles, but especially for those molded in place. Tests have shown that short columns molded on a side, but tested on end, were superior to similar blocks molded and tested on end.

In foundations on poor soil, etc., where low grades of concrete are employed, it is important that they be thoroughly mixed and be deposited with particular care so as to assume uniformity and as great solidity as possible.

In water front work, an impervious exterior surface is most important. See that forms are uniformly plastered with a specially rich mixture, or that the front is thoroughly spaded next the forms to work large pieces of aggregate back from them. In addition, the surface should be thoroughly grouted and troweled immediately after the forms are removed, so as to fill all pits left by air bubbles and drops of water.

Concrete brick and blocks, if molded with a dry mixture, should be kept saturated by constant sprinkling for a long time after molding.

Be exceedingly careful about joints between portions of work done at different times. Unless the masses on the two sides of the joint are absolutely alike in quality, the joint will be visible and no amount of surface treatment except by stucco can entirely eradicate the blemish.

Be exceedingly careful about joints between different day's work. See that they are absolutely clean and vertically cut. Work may be roughened to good advantage, but should never be left with a slanting surface or with loose material covering it.

Work can be stopped for the night along almost any line, if proper care is taken in joining work and if work is continued after an interval not exceeding 48 hours, while the old concrete is still comparatively fresh.

Shrinkage cracks are more likely to occur along such joints than at any other points. The best method of making them as water tight as the remainder of the floor is to cover them with a strip of waterproofer's felt swabbed on with hot tar.

Unless adjoining masses of concrete of different depths (like adjacent girders and slabs), have the puddling or ramming operation carried down as thoroughly through one as the other, initial setting cracks are likely to form between the masses of different depths.

Efflorescence seems to take place because moisture seeps to the surface at cracks or rough spots where the skin coat of grout has been rendered pervious.

The remedies seem to lie in the direction of more impervious concrete, not too wet mixtures, well puddled, with great care exercised at joints and in depositing materials so as to preclude superficial cracks even of minute size.

Have cement piled in lots of a few hundred bags each, in regular tiers and rows, with each tier and row eight or ten bags high. Make the contractor use cement in regular order, the oldest first. By such a method of piling the amount used each day can be readily checked.

If the mixture is handled in large cars or buckets, an inspector at the mixer can be omitted, because the one at the place of deposit, if at all expert, can instantly detect any alteration in the mixture by its color and texture.

If reinforcement of small diameter is employed, like quarter-inch rods or wire in its various commercial forms, be careful to have it stretched so as to remove absolutely all waviness and slack. Otherwise, sagging of finished floors is likely.

To Contractors.

The more intelligent the labor employed in placing concrete, the better the result. Experienced labor at $3 is more economical than at half the price if the latter is indifferent, independent and inexperienced.

The more care exercised in placing concrete, the more perfect the surface secured, and the less the liability of cracking and efflorescence.

Don't try to build thin walls or intricate ornamental work in place. For the latter, make castings and set like stone work. It is better to set such cast work as the work progresses. If this can be done, the blocks should be as long, wide, and deep as possible. If cast work is to be set in recesses left in the mass work, the blocks should be as thin as possible consistent with ease of handling. They should be reinforced. In each variety cast into the blocks means of handling them, such as hooks, lewis holes, etc.

In large block work, blocks should be so designed as to secure a good bond with the mass work, by slots, projecting reinforcement, etc. Where blocks are to be set in prepared recesses, special metal ties must be set in the mass work and corresponding arrangements made in the blocks to fasten the veneering to the face of the work.

Even on small work, a derrick with bucket, so arranged as to handle the whole of a single batch direct from the mixer to the place of deposit will be found of value. It will do away with special hoists, hoppers, wheelbarrows, runways, etc., and requires less inspection because there is less possibility of accidentally mixing poor batches unnoticed.

In purchasing a concrete mixer, be careful that there is ample power, but that the machine does not run too rapidly. High speed is useless for proper mixing and is injurious to the machine. Very slow speed is not objectionable but requires more time for the proper mixing of each batch and may thereby be costly.

Do not try to fill the mixer very full. The spilling is apt to lose more material and cost more for cleaning than the gain in time.

Use power to handle forms, reinforcement, etc., as far as possible. Money is saved thereby. A light derrick so located as to reach most parts of the work is money well invested.

Secure an organization in which each man has a definite thing to do, a special routine to go through, and keep him at it. Don't break up such an organization by shifting men from place to place each hour or day. When you get such an organization, keep it intact. Don't break it up by working short hours. Arrange matters so that there is something always at hand to do on rainy or cold days to keep the organization together and good natured. Get the machine to run without jar and noise and keep it going. This will require careful planning at the start. Lay out the campaign as does a general invading a new country. Make a schedule of everything, down to the dates for delivery of nails and spikes, the number of men of each kind to be employed and the dates on which each part is to be completed. You won't keep to the original plan, but it will be a spur and should be prepared just the same.

Make a careful estimate of each kind of work and keep as careful a record of its cost. Make the general foreman cut under your estimate and make it worth while for him to do so as deeply as possible.

Do not allow cement bags to be used for miscellaneous purposes. They have been known to get into reinforced concrete beams where they do not make good material.

Forms.—Design forms as carefully as the structural engineer makes up his reinforcement. Design reinforcement, forms and methods of filling them, so that they may be readily cleaned of shavings, sawdust, snow and refuse in general. This applies to columns especially.

Column forms should be water-tight. Use tongued and grooved material.

In designing centering, so arrange it that practically no end grain comes against concrete. Avoid this by capping the ends of boards with cleats. Design centering so that the main parts can be struck without disturbing the beam and girder bottoms.

If proper care is exercised and a good design worked out, but one floor of center (aside from bottom boards and some supports), need be employed on any building unless a high rate of speed is required. Always use tongued and grooved or bevel edged material for forms. The resulting work is far superior.

It is no mistake to use amply thick and heavy material for forms, especially if they are to be used a considerable number of times. Thinner material is easily broken, requiring more labor for repairs than would pay for the extra thickness.

Order materials cut to sketch and have as much work as possible done in a shop. So design work that bolts and a wrench are the principal tools to be used in erecting and removing the forms. Do as little work with hammer and saw as possible. Make it almost a crime to cut a piece of timber. Use neither very dry, nor very green timber for forms. One swells too much, the other not enough or too irregularly.

Try to get beams and girders designed of dimensions so that stock sizes of lumber may be employed.

For wall forms, bolts are better than wire. They must be absolutely straight or it may be impossible to remove them. Unless special devices have been employed for their easy removal, they should be taken out within a very few days after the concrete has been deposited, even though it may be thought advisable to let the forms remain longer in place. Replace a few of them with smaller rods. To obviate early removal, use a tin tube or piece of pipe through which to pass the bolt. The bolt may be wrapped loosely in oiled paper or coated with heavy grease. Its removal will then be more certain. The pipe, if used, will act as a spreader for the forms as well as a sleeve for the bolt. Concrete blocks can be molded and used similarly, but they present a bad appearance in the finished wall. Tapered wooden pieces, bored to receive the bolt, are also good, but should be well greased and be driven out as soon as the forms are removed. Probably the best method is to use spreading strips unattached to the bolts and remove them as the concrete is deposited. Only the well greased bolts then remain in the concrete and when they are removed only a very small hole remains to be filled. Bolts through forms should never be within a foot of a finished concrete edge if possible to place them elsewhere. They are likely to break the concrete during their removal, especially if not absolutely straight.

Design wall and other long forms so that wedges are employed between the side boards and the main braces. By this means, the wall may be maintained in line until the concrete is partially set. This is especially necessary where permanent spreaders are not used in erecting the forms. This aligning requires an expert, and the beauty of the finished work depends on his work.

Be careful to have form material, especially the face boards, of absolutely uniform thickness. This should be exacted even though it is expected to dress the finished surface by picking, bush hammering, or some similar process. With boards of different thicknesses the cutting has to go to much greater depths from the original surface where the thin boards were used and this is apt to expose a very different quality of material.

Where columns are of cast iron or steel, it is possible so to design centering that it can be erected a story or more in advance of the depositing of concrete. This requires more sets of forms, but allows more rapid progress, especially in winter when the extra floor provides a complete enclosure which can be properly heated to prevent damage to the concrete before it sets properly.

Use a steam or compressed air jet to clean the forms just before concrete is deposited. In winter, a jet of steam is useful in thawing snow and ice in heating the forms so as to prevent chilling the fresh concrete. This last point is especially true with regard to the reinforcement and in a noteworthy degree if cast iron or structural columns are employed.

The use of such a steam line will be found financially and practically most advantageous.

Give beams and girders a slight camber.

Grease forms to preserve them and to aid in their ready removal. Use as little grease as possible if the finished concrete surface is to be plastered. When other methods of treatment are contemplated more grease is profitable. A combination of crude oil and kerosene gives good results.

Forms lined with sheet metal will show nail heads, and a wavy appearance unless heavy material is used. The nails may be employed only around the edges of heavy sheets, which, if cut to a predetermined size may have the edges covered by bevel pieces to give the finished surface the semblance of blocks.

Heavy paper may be used to line forms, but its use needs constant attention in order to secure satisfactory results. Unless it is very oily it will stick to the concrete so that it is sometimes necessary to burn it off, even thorough soaking not being entirely effective. It is exceedingly difficult to keep it absolutely smooth, so that the final surface does not show wrinkles.

When appearance is unimportant, and a ready laid floor is available, it is very economical to lay paper on the floor with proper separating strips, and cast roof or floor slabs thereon. They can afterward be hoisted and set in place. This method will allow more rapid progress to be made with the structural part of the building.

Use fire clay to close joints, knot holes, etc., in forms just before concrete is placed. Delegate to one man the careful inspection of forms to see that all temporary nails are removed just before concrete is deposited, so that portions of forms intended for easy removal will not be found tightly nailed when the workmen come to strike them.

Metal forms are more economical than wood for cylindrical column molds, especially where considerable repeated use can be made of them, as in casting shells to be used for column forms. Metal forms may also be used to advantage for the erection of small buildings, either in sheets of sufficient thickness to resist the lateral pressure of a few feet of liquid concrete, or when backed with timber to form walls of greater height.

Handling and Placing Concrete.—Gravel and small broken stone are cheaper to shovel than the larger sizes. For everything except the smallest sizes of aggregate, use boards or metal sheets as platforms, to give shovelers a surface along which to work.

In walls, columns, etc., the aggregate should not contain particles of maximum diameters greater than one-third the distance between faces of adjacent reinforcing members, or between faces of forms and reinforcement. Otherwise voids may be expected through arching of pieces of the aggregate. Gravel is less liable to do this than broken stone.

Use a comparatively liquid consistency of concrete. It should be such that there is not quite enough water to wash cement from aggregate when dumped in large masses.

Puddling is quite as effective as ramming, if properly done.

Use a small batch of mortar for the bottoms of columns and at the start of a day's work, and a final batch largely of aggregate for tops of columns. Otherwise, the bottom of a column is likely to be all stone, and the top all grout or possibly nothing but water.

Where fine detail must be cast in the work, use either a comparatively dry mixture and place it and ram it with great care, or use a very wet mixture and puddle well, so building the forms that a considerable pressure head will be produced at the level of the ornamental work.

If stucco is to be applied to the surface, rough timber may be used for forms and no care exercised to see that the surface as left by their removal is at all smooth. Further, it is wise to cast dovetailed recesses in the mass work. This can be done at little extra cost.

Very wet concrete gives a more homogeneous mass than drier mixtures, unless special care is exercised in depositing the latter. The wet mixture is therefore the more economical to handle. A very wet mixture, however, will reveal the exact nature of the forms in great detail, including all defects and faults of surface and workmanship. If surface finish is of importance, the drier mixtures are preferable.

Do not try to mold in place such things as window sills with slightly sloping top surfaces. Even with considerable pressure heads, results are never certain. The top surface is apt to be filled with air and water bubble holes, impurities in the sand and cement, etc. If molded in place the surface must be carefully troweled like a sidewalk. If cast, to be inserted like a stone sill; it should be cast upside down.

If walls or floors are to resist water pressure, take especial care at the joining of different day's work. In floors, use asphalt or coal tar with a strip of felt. In walls, both horizontal and vertical joints must be equally cared for.

Concrete is not necessarily damaged by freezing. It is damaged, however, by rapid alternations of thawing and freezing before the final set is attained. In large masses, concrete can be deposited even at low temperatures and without heating materials, if a possible slight disintegration of the surface is not objectionable. In thin walls, floors and especially columns, of buildings, however, materials should be heated and work amply protected in cold weather. Do not depend solely on canvas spread directly on the surface as a covering to protect concrete from freezing. Hay, shavings, or some other material in which quiet air is entrained, on top of the canvas is necessary. An air space beneath it is also valuable.

If wheelbarrows are used, be exceedingly careful about having well laid out and well supported runways for them. The constant jarring caused by poor runways probably did much to produce a late failure.

If a derrick and buckets are used, the latter should be of the bottom-dump type, which can be lowered on to the centering or a chute, the bottom tripped, and then the bucket raised slowly, allowing the concrete to flow out slowly in a stream.

A bucket with a sliding side gate is next best. Do not use a tipping bucket or one which will produce heavy vibrations when the contents are dumped.

If possible, place the mixer high in the building and hoist concrete ingredients to it in bulk.

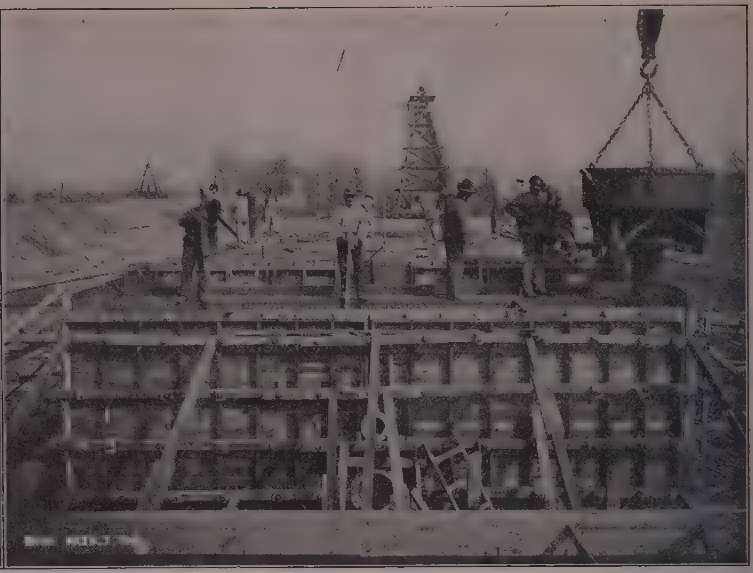
A few extra men to maintain proper runs for wheelers, on large jobs, will often actually effect an appreciable saving. The wheels should never turn abruptly, but be led around in a circuit.

The Wabash Bridge near Decatur.

A concrete skew-arched bridge is being built by the Wabash R. R., near Decatur, Ill., over the Sangamon River, in connection with the reduction of grades and double tracking on several miles of the line in that vicinity. The structure is on a skew of 45 deg., with its piers and abutments parallel to the stream flow. It consists of four arch spans, the end ones being each 92 ft. 11 in. long, and the two center ones 100 ft. each. The arches have a rise of 30 ft. and a height above the stream bed of 62 ft. over the channel. The bridge is designed for a loading of two consolidation locomotives, Cooper's E-50 class, followed by a train load of 5,000 lb. per lineal foot, with impact added. The pier footings rest on piles and are reinforced with 1-in. corrugated steel bars, but the arches are designed as plain concrete structures, steel being used only to resist temperature stresses. The abutments are U-shaped in plan and extend back 126 ft. along the center line of the bridge. Instead of the space within the abutments being filled with earth the abutments are hollow, being divided into four compartments by two horizontal slabs, one supporting the track and another 24 ft. 6 in. below it and two cross walls. The bridge was designed by Mr. A. O. Cunningham, chief engineer of the Wabash R. R., and is being built by the Wm. P. Carmichael Co., of Williamsport, Ind. It will cost about $177,000.

TESTS OF A MEDIUM PRESSURE SIMPLE LOCOMOTIVE with superheated steam on the Atchison, Topeka & Santa Fe Ry. show that an economy in operation of within 5 per cent. of that of the high-pressure compound locomotive may be secured, while the boiler troubles from the high pressure and the extra maintenance of the compound gear are avoided entirely. The engine under test has 32x32-in. cylinders and ample boiler capacity, the pressure used being from 130 to 150 lb., with from 30 to 40 deg. superheat. The engine not only required far less repair work than compound engines of similar size, but also handled much more satisfactorily the bad foaming waters of New Mexico.

Site of Clear-Water Reservoirs.



Filling the Filter Forms.

CONTRACTOR'S PLANT AND METHODS WATER PURIFYING AND SOFTENING WORKS, COLUMBUS, OHIO.

By George E. Howe, Resident Engineer.

In The Engineering Record of Feb. 24, 1906, there was a description of the purifying and softening works being built by the City of Columbus, Ohio, to purify and soften its water. This work has been under construction since July, 1905, and is at this date about two-thirds completed.

Since the article above mentioned was written there has been let an additional contract for the construction of a pumping station to house the pumps to be used for supplying the purifying and softening works with water and to deliver water from them to the city. A general description of these works is as follows:

An intake, with a gate house to be situated on the bank of the Scioto River to control the flow, will deliver water through a reinforced concrete conduit to a suction well near the pumping station. This station will comprise a 68x140-ft. engine room, a 48½x136-ft. boiler room and a 26x109-ft. coal pocket, and will contain the pumps, boilers and auxiliaries necessary for delivering 40,000,000 gal. of water daily from the river to the purifying and softening works, and the same quantity from the purifying and softening works to the city. The foundations of the building, the coal pocket and the boiler room roof are to be of concrete.

Water is to be delivered from the pumping station through a cast-iron force main to the purifying and softening works just north of the pumping station.

The purifying and softening works consist of a 51x59½ft. head-house, six saturator tanks covering an area 59½x79½ ft., two mixing tanks occupying a 59½x204-ft. space, six settling basins lined with puddle and concrete and covering a 350x400-ft. area, a 33x45½-ft. laboratory building, and two clear water reservoirs measuring 214x218 ft. On top of each clear water reservoir are to be five mechanical filters, 28x49-ft. monolithic concrete tanks, each with a capacity of 3,000,000 gal. daily. All the substructures are built of concrete, and the superstructures of brick, faced on the outside with red pressed brick with a concrete trim, with slate roofs. The inside of the engine room of the pumping station is to be faced with buff speckled brick.

As laid out, the purifying and softening works are within a 500x700-ft. rectangular area, extending nearly east and west, the settling basins at the westerly end, the filters and clear water reservoirs at the easterly end, and the saturators, head house and mixing tanks in between.

To handle the material for this plant, the contractors have erected two 5-ton Lidgerwood traveling cableways with a 760-ft. span and placed two service tracks of a 3-ft. gauge along the south side of the plant. On the extreme west of the property is the stock yard for pipe and specials, lumber, steel, brick, and other supplies. Along this area a siding has been built connecting with both the Panhandle R. R. on the north side of the property and a trolley road in the highway on the south side of the property, giving a switching service to the Hocking Valley and Big Four lines. From this siding spurs run to the cement sheds of 5,000 barrels capacity, to the concrete stock bins located just west of the settling basins, and to a gravel pit on property just west, where some of the concrete material has been taken out.

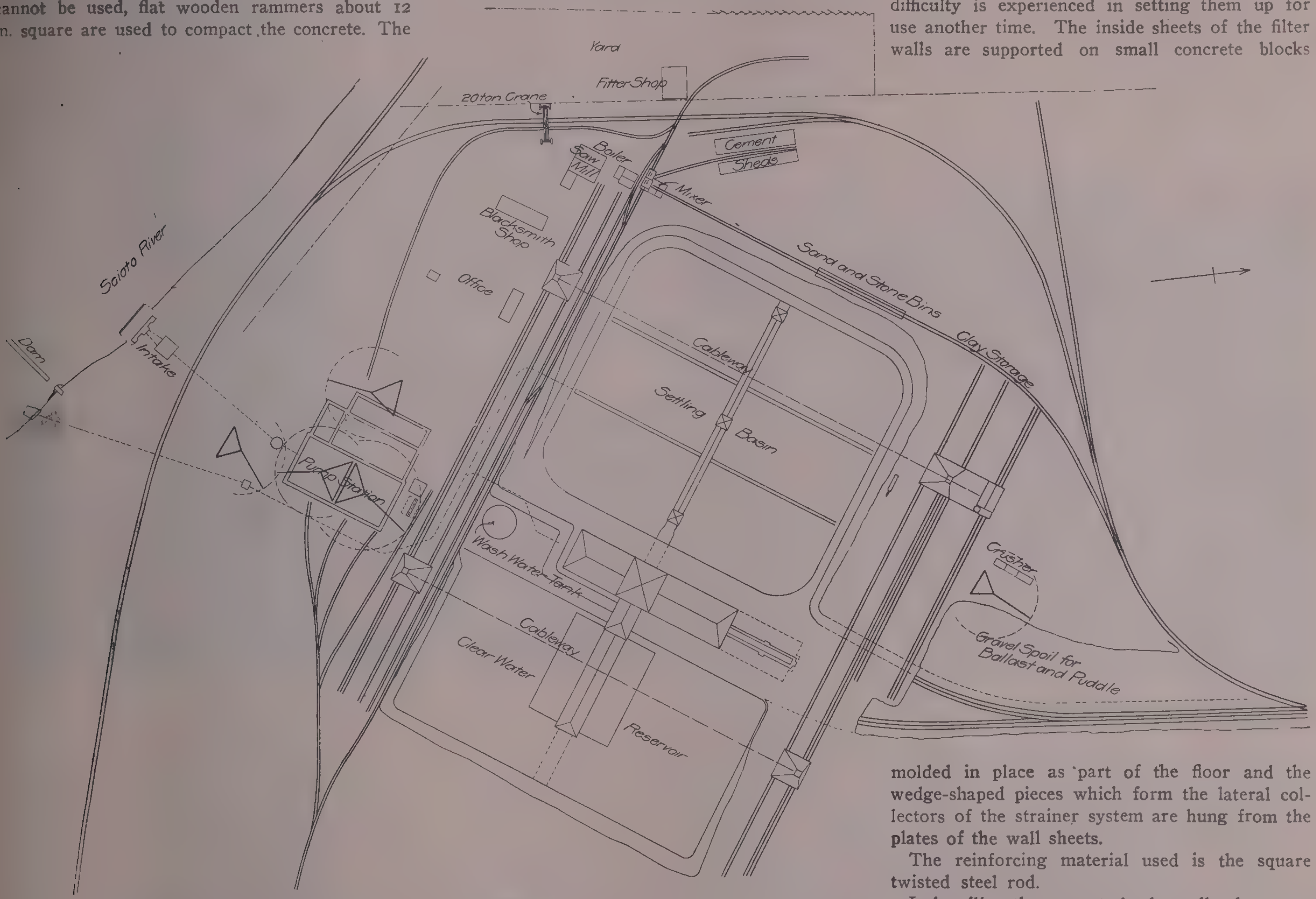
The spur to the concrete stock bins runs up a trestle, under one end of which the clay used for the puddle was stored. At the other end of this trestle are the four bins for the sand and the three grades of stone used in the concrete. Each bin holds about 200 cu. yd. These bins discharge through gates in their bottoms into 1-cu. yd. dump cars which run in a tunnel underneath the stock bins. These cars are drawn up to the top of the mixing tower by a double-drum hoisting engine located at the top of the tower. The other drum of this engine is used to haul cement from the cement sheds to the charging floor of the mixing tower. At the top of the tower, which is about 40 ft. high, are four bins each 10x10x108 ft., for the stock. These discharge through chutes controlled by sliding gates into a square hopper, partitioned into four divisions, on the floor below. These divisions are filled to heights indicated by gauges on the side of the hopper. The cement, which is handled in cloth sacks, is dumped in, and then a trap door in the bottom of the hopper

Settling Basins.

Headhouse Foundations.

is released and the charge dropped into a 1-cu.-yd. Smith mixer on the lowest floor. The water, which is measured in a steel tank having glass gauge tubes on its side, is controlled from the charging floor, the filing and emptying cocks of the tank being yoked together and operated at the same time. After about six to eight turns in the mixer, the charge is dumped into buckets placed on flat cars and is hauled over the various 3-ft. gauge service tracks to the cableways or derricks about the plant.

The concrete is mixed quite wet, as a rule just so that a little water stands on the surface, and after it is in place in the forms it is well spaded with common garden spades or punched with strips of lagging. In places where wet concrete cannot be used, flat wooden rammers about 12 in. square are used to compact the concrete. The grades of stone used are three in number, ¼ to ¾ in., ¾ to 1½ in. and 1½ to 3 in. Up to the present time Whitehall Portland cement has been used. The concrete is proportioned by Mr. Wm. B. Fuller's parabolic method described in Taylor and Thompson's work. At first samples of the ballast were analyzed frequently, but it was found that changes in the character of the ballast were readily visible to the eye and later samples were only taken when the character of the ballast appeared to change.



Arrangement of Contractors' Plant, Water Purification Works.

The forms are in general built of ⅞-in. tongued and grooved lagging nailed with 8d nails to 2x6-in. and 2x8-in. studs, spaced 18 to 24 in. apart on centers. For the greater part of the wall work, they were made up in sheets 4 to 6 ft. high, and 10 to 16 ft. long. These sheets have been used over and over, some of them twenty-five to thirty times, with but few repairs. The forms are held in place by 4x4-in. waling pieces spaced from 3 to 4 ft. vertically and fastened about every 4 ft. by a ¾-in. round rod. The rods are cut from 2 to 4 in. shorter than the space between the forms and threaded, with a pumprod coupling placed on the threaded ends. Stubs threaded at both ends finish out the rod. When the forms are struck the stubs are screwed out of the concrete and used again. The small hole left by the stub is easily filled by the finishing gang and there is not a lot of wire ends left on the face of the concrete to ultimately rust and discolor it. The forms for the groined arches in the clear water reservoir were of the usual type and were allowed to stand about a week before being struck. A round taper pin 1 in. in diameter at the small end was placed through the concrete into each center and driven out when the concrete had set. When the forms were struck they were lowered by ropes running from above through the holes and the holes were then filled with grout. Forms sufficient for half of one clear water reservoir were built and after having been used four times were torn apart and the material used for the filter forms.

In general the wall forms were struck the day after the concrete was placed in them and the finishing gang set immediately at work on the exposed surfaces. These surfaces were finished with a thin mortar grout rubbed into the concrete with either a wooden float or a piece of sacking and then brushed over with a wet plasterer's brush. Such a treatment fills all the holes due to the little air bubbles on the face of the forms and smooths over places where the lagging is uneven, and when applied to fresh concrete leaves a very smooth and uniform surface. Care has to be taken, however, to see that the men do not get a coat of the grout on similar to a skim coat of plaster, as that will surely peel in cold weather.

An exception is to be made in the basement of the pumping station, where the contractors are to hammer the walls, giving them a four-cut surface. In doing this work they intend to use air hammers.

So far as possible the conduit forms have been made collapsible. In building the drains and the 5-ft. reinforced conduits, which were built monolithically in sections of from 30 to 40 ft., each section of the forms 10 ft. long was set on a block of concrete 6 in. square cast in place, the top of this block being rounded to fit the invert. About every 5 ft. the contractor placed a block of lean concrete 12 in. thick, 2 ft. wide and 4 ft. long, and in these blocks set loops of No. 7 wire. The forms were fastened down to these loops by wires. This method proved to be very effectual in preventing the forms from floating from the upward pressure of the wet concrete.

The filter forms were built for two filters, all the pieces being numbered when in place, and no difficulty is experienced in setting them up for use another time. The inside sheets of the filter walls are supported on small concrete blocks molded in place as part of the floor and the wedge-shaped pieces which form the lateral collectors of the strainer system are hung from the plates of the wall sheets.

The reinforcing material used is the square twisted steel rod.

In handling the concrete in the walls, the greater part of which are 24 in. or less in thickness, the baffles of the mixing tanks being only 6 in. thick and the filter walls 9 in. thick, the Hains bucket has been of exceptional service. This bucket, which is a cylinder with a hopper bottom closed by two sliding gates hinged together, can deliver concrete in a sheet about 2 or 3 in. wide and 18 in. long, and when hung from a traveling cableway can readily place concrete in a 6-in. wall. It has a further advantage in that it dumps gradually and does not strain the forms, as does a bucket which dumps all its contents at once. Those in use at this plant are of a two-yard capacity.

The main dividing wall, saturator tanks, headhouse and mixing tanks were built in three-lift sections, being laid out between expansion joints so as to get monolithic construction as far as possible. Steel plate ¼x14 in. was used at expansion joints, one half of the width of the plate being held on one side of the joint and the other greased so as to slip on the other side of the joint. Sections were picked out so as not to exceed about 200 cu. yds. in volume, and once concreting was started nothing was allowed to interupt it. The mixing tanks were built in sections about 9 ft. high, the width of the tank, 59½ ft., and 30 ft. long. The filters are built in one operation, and the 110 cu. yds. of concrete in one of them, making the closed tank, floor, walls and roof, is placed in about eight hours. It takes, however, from two to three weeks to take down and set up the forms for a filter and place the steel and air pipes.

The largest day's work with the concrete plant was about 420 cu. yds. in 14 hours. The plant readily turns out 30 cu. yds. an hour in ordinary work and in the season just passed has handled 27,000 cu. yds.

The puddle used for lining the settling basins and for covering the roof of the clear-water reservoirs is mixed in a Drake continuous mixer and carried to place by the cableways. It is rolled until hard by a five-ton grooved roller manufactured by the Kelly-Springfield Co. The materials used are 2 parts of gravel from the excavation, passing a 1-in. screen, to 1 part of clay. The clay is brought from the neighborhood of Zanesville, Ohio. The gravel analyzes about one half finer than ¼ in., and care is taken to maintain that proportion of finer material in it at all times. The gravel is taken from a spoil bank at the north side of the plant by a ¾-yd. clamshell bucket operated from a stiff-leg derrick mounted on rollers, and is dumped into a portable jaw crusher to size it. The rejects from the 1-in. screen are stacked for use as ballast for the paving in the settling basin and for the railroad siding. The puddle is placed in 6-in. layers, allowed to dry, and thoroughly rolled before the next layer is placed. The slopes of the basins, which are too steep for the steam roller, are rolled by a home-made roller constructed of three 36-in. pulleys with 12-in. faces, placed side by side and filled with concrete. This roller is handled by the cableways and has proved very effective.

The excavation is wholly in loose gravel and practically free from water. That part of the excavation for the purification works in the settling basins was handled by wheel scrapers and a Western grader and dump wagons. This material was placed in 6-in. layers in the banks of the settling basins, stones over 3 in. in size being picked out, and each layer was rolled down with a grooved roller weighing 2,000 lb. to the linear foot. The bulk of the other excavation was handled by a small steam shovel, the material being hauled by dinkey locomotives in 3-cu. yd. dump cars to the fill for the railroad siding from the Panhandle R. R. The average haul there was about 1,600 ft. In excavating for the foundations of the pumping station, a Hayward orange-peel bucket hung from a stiff-leg derrick mounted on rollers was found to give the best service.

In addition to the concrete and puddle plants described above, the contractors used stiff-leg derricks for handling the concrete in the foundation of the pumping station.

They have near the concrete mixing tower a saw-mill and a blacksmith's shop. The saw-mill contains a hand saw, circular saw table, swinging cut-off saw, jointer, buzz planer, boring machine, thread-cutting machine, drill press, hack saw, emery wheel and grindstone. In this mill all the lagging for forms is cut to length, ribs cut out, the wedges made for the forms for lateral collectors in the filter, and also all the rods and bolts needed in the plant are threaded.

For unloading the heavy castings and machinery for the pumping station a twenty-ton crane has been set up on trestle bents directly over the main siding and a service track.

The contractors for the purification and softening works and the pumping station are Messrs. Westwater & Casey, of Columbus, Ohio. Mr. Ottomar Stange is the contractor's superintendent. The equipment for the pumping station is being furnished by the Holly Manufacturing Co., of Lockport, N. Y.

Interior Forms for Filters.

The Concrete Mixing Plant.

The West Side Railroad of the New York Central system in Manhattan, over which freight is delivered to the long line of warehouses and commission stores near the North River has been a source of contention for a long time. It has been claimed that the switching of cars through the streets was a great annoyance to traffic and to people in the vicinity, while the railroad has frankly stated that the conditions were extremely unsatisfactory from its point of view. The situation was at last taken in hand by the Legislature, which ordered the tracks removed from the street surface. This week the railroad company agreed to place its tracks underground on Eleventh Avenue between 60th and 30th Sts., but no agreement has been reached concerning the position of the tracks south of 30th St. The company has asked for a franchise for an elevated structure for this part of its line and has refused to accept the suggestion of certain city authorities for a depression of its tracks. This refusal is based on the alleged impracticability of running cars into docks and warehouses from a subway, which would destroy the value of the railroad service and render useless many buildings designed specially for receiving carload shipments.

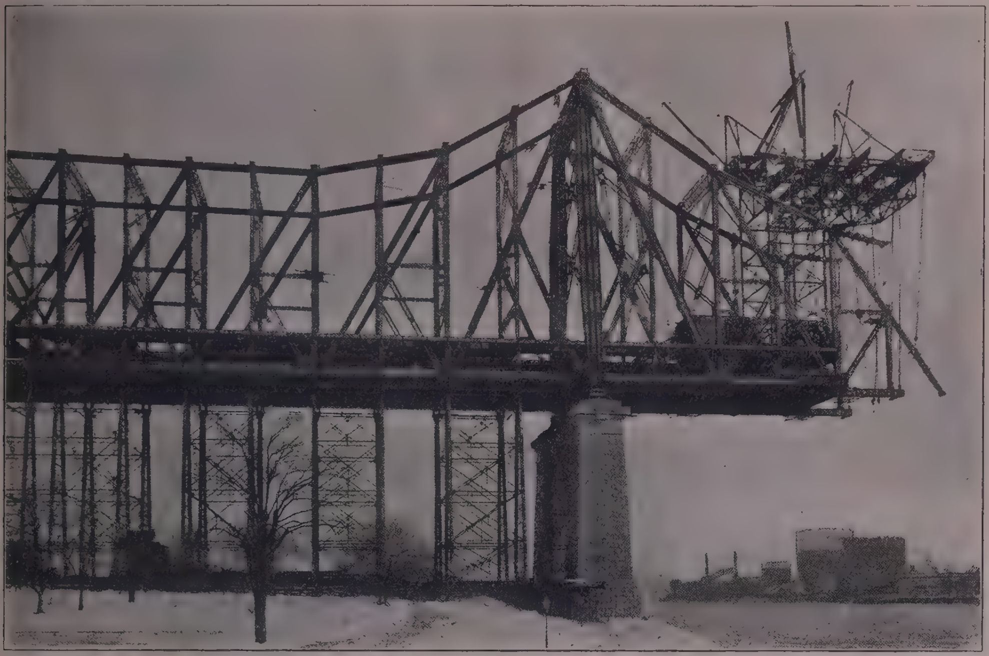
Erection of the Cantilever Spans of the Blackwell's Island Bridge.

The Blackwell's Island bridge across the two channels of the East River and over Blackwell's Island will comprise between the foot of East 59th St., New York, and Ravenswood, Long Island, five main spans of 469½, 1,182, 630, 984 and 459 ft., respectively, commencing at the New York end; and will weigh about 50,000 tons, according to the original estimates. The channel spans, although not as long as those of the Forth and Quebec bridges, are much longer than any others yet constructed, and considering the capacity and size of members involved, excel all others. They are made with two continuous lines of pin-connected trusses 3,724½ ft. long from end to end in vertical planes 60 ft. apart. The maximum depth of the trusses is 185 ft. and their clearance above mean low water is 135 ft They carry two decks, the lower one having cantilever extensions increasing its width to 90 ft. It has a capacity for one highway, two sidewalks and eight lines of railroad track providing for an estimated traffic of 150,000,000 passengers annually. The pin-connected trusses are made of 16-in. eye-bars and multiple-web compression members, the latter being in two sections, each having lengths up to over 100 ft. and weights of 78 tons. All secondary connections are field-riveted and all members except the eye-bars are of riveted construction. A notable feature of design is the construction of all main vertical and diagonal members in two sections, each pin-connected in the middle to facilitate handling and erection. The main transverse bents on the piers are exceptions, in that their massive inclined posts are made in several sections field-riveted together.

Preliminary surveys were made in January, 1899, and the contract for the superstructure was awarded in November, 1903. The installation of an erection plant costing several hundred thousand dollars was commenced on Blackwell's Island on Aug. 6, 1904, the first steel was received at the site on Feb. 17, 1905, and the erection of the trusses of the island span was commenced on Sept. 9, 1905, after the pedestals and girders had been set on the island piers.

A 55x400-ft. dock was built by the contractors just above the site of the 630-ft. span on Blackwell's Island and equipped with a steel derrick having a 75-ft., 65-ton boom, which unloaded materials from the lighters and delivered them to cars hauled by cables to a pair of 65-ton gantries These had an 85-ft. span and 30-ft. vertical clearance running on a 500-ft. track and providing for the storage of bridge members in classified piles. Each gantry is operated by six electric motors driven by a current generated in the contractor's adjacent power house, which is equipped with a 480-h.-p. battery of boilers, air compressors, pumps and other machinery.

The schedule of operations provided for the erection of the 630-ft. span on steel falsework about 120 ft. high, followed by the erection of the cantilever arms of the channel spans adjacent to the island span simultaneous with the erection of the 469½-ft. and 459-ft. end spans on the same falsework released from the island span. Finally the end spans will serve as shore anchors from which the remaining halves of the two channel spans will be erected as cantilevers to meet the portions previously built out in both directions from the island.

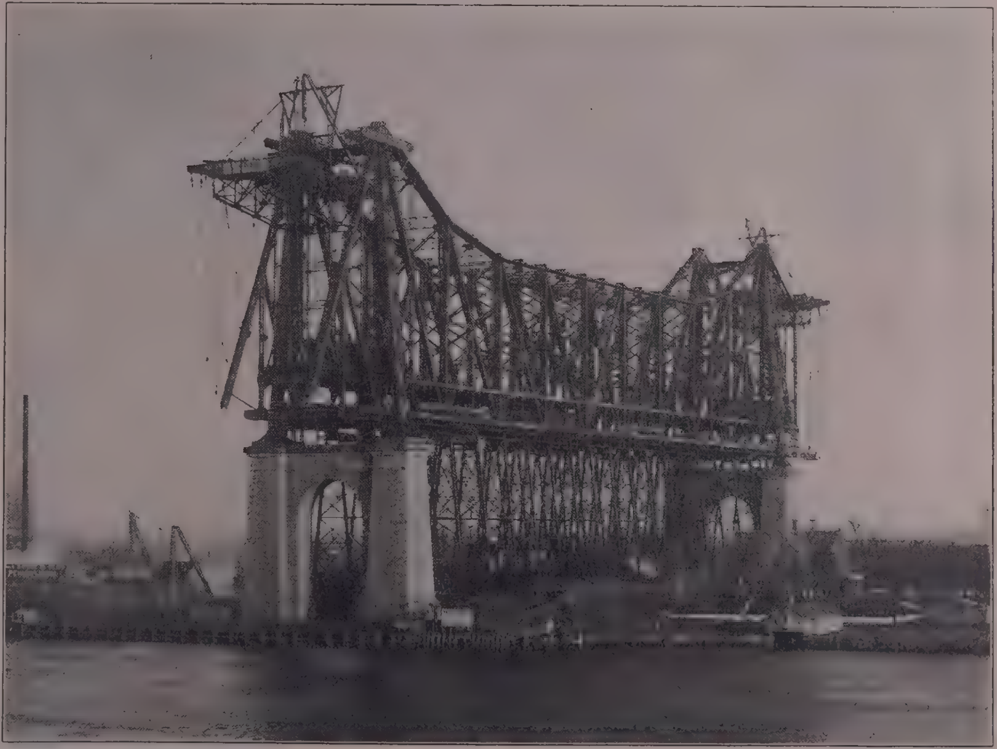


Erecting Fifth Panel of East Channel Cantilever.

Preliminary erection work was commenced in January, 1905, by the erection of about 1,700 tons of steel falsework for the island span. This consisted of a series of double pyramidal towers with interchangeable upper sections, assembled in the field with service bolts instead of rivets to facilitate its removal and re-erection for the end spans. A wooden derrick was erected on pier II, and with it a 30-ton steel derrick was also erected on the pier and in its turn erected the first panel of falsework. A wooden traveler, having a horizontal rolling platform with a 55-ft., 10-ton derrick boom mounted on each of the forward corners, was assembled on top of the first bent of falsework and erected the remainder of the falsework. A plate-girder platform was built on top of the first falsework towers, and on it was erected a 65-ton stiff-leg derrick with an 85-ft. boom, with which the 30-ton derrick was removed in April, 1905, and the 72,000-lb. sections of the 260,000-lb. cast pedestals were erected in September.

In the beginning of October the derrick commenced the erection of the first panel of the 630-ft. span and subsequently erected the No. 1 steel traveler, which had a horizontal rolling platform about 41 ft. square with an 85-ft., 65-ton steel derrick boom at each forward corner. The traveler and its equipment weigh about 400 tons and worked across the span, erecting it from pier I to pier II, moving forward one panel at a time, assembling all of its members complete in each position, until it had erected all of the structure up to the middle of the trusses. This work comprised the handling of about 11,000,000 lb. of steel, including all of the heaviest members in the span. Materials were loaded by the gantries in the storage yard on material cars on surface tracks which delivered them alongside the bridge axis to the traveler derrick which hoisted and assembled them without rehandling.

Erection was completed up to the middle of the truss on Dec. 2, 1905, and afterwards traveler No. 1 erected on the upper deck at the center of the span, the first No. 2 traveler. This consists essentially of a Z-shaped steel tower 120 ft. high, with top and bottom cantilever extensions. It weighs with its equipment about 500 tons and from it was erected the duplicate No. 2 traveler. Each traveler was equipped with 34 sets of tackles with capacities of 10 to 40 tons each, suspended from the jigger beams, and with a 65-ton stiff-leg derrick having an 85-ft. boom which was seated on top of the traveler in the middle of the forward bent. A crew of about 120 men was required to operate both travelers, which moving away from each other toward the ends of the span, completed the erection of the upper parts of the trusses and the transverse and lateral bracing weighing together about 6,400,000 lb.



Completed Island Span, Falsework and Cantilever Travelers.

Materials from the storage yard were delivered on the service tracks to a 65-ton steel derrick seated on the upper deck near the center of the span, with its mast in the axis of the bridge. This derrick hoisted the members and distributed them on standard-gauge service cars running on tracks laid on the cantilever extensions of the lower floorbeams and delivering to the No. 2 derricks as required.

Although the erection was delayed about 3½ months by labor troubles, the last pin in the 630-ft. span was driven on Dec. 4, 1906. In order to drive the pins, at the tops of the pier posts, care was taken to level up the bottom chord to the calculated camber curve by jacking on top of the falsework towers with the 500-ton hydraulic jacks provided for the purpose. As the weight of the span, falsework and travelers amounts to about 15,000 tons, considerable settlement had occurred, and the jacks were operated from time to time to lift the steel several inches to preserve the alignment. As the erection of the cantilever arms will reverse the stresses as well as the camber in the island span, the final positions of the pier posts differ from their first positions and it was necessary to erect them with their tops inclined toward each other. This was successfully accomplished by bending the tops of the post inwards with a system of telescopic struts and hydraulic jacks described in The Engineering Record of Nov. 3, 1906. The device worked successfully and the final pins were driven without difficulty by the ordinary rams previously used for the other pins.

The members of the cantilever arms connected to the top and bottom chord pins in the pier bents were assembled when these pins were driven, and in order to support them temporarily in their approximate positions while the traveler was moved forward, their outer ends were carried by cantilevers consisting of regular floorbeams 56½ ft. long and 6¼ ft. deep, borrowed from the permanent structure.

The first panel of the lower chord beyond the pier is 40 ft. long, weighs 93,870 lb. and is spliced to the last panel of the island span about 12½ ft. beyond the pier center. It was supported about 34 ft. beyond the pier center on a transverse timber seated across the top flanges at the outer ends of a pair of floorbeams 4 ft. apart on centers, which were temporarily fastened together by solid transverse diaphragm plates stiffened with diagonal angles and bolted to the vertical web stiffener angles, thus forming a twin girder which was supported at two fulcrum points about 6 ft. on each side of the pier center by timber cribbing built up about 4 ft. above the masonry. Each point of support on the girder flange was about 3 ft. wide and the reactions at the rear or shore end of the floorbeams were taken up by timber blocking wedged between the ends of the top flanges and the lower chords of the trusses.

Each top chord panel has twenty 16x2⅛-in. eyebars weighing altogether 60 tons, and was supported at an angle of about 45 deg. with the horizontal from a pair of separate floorbeams one on each side of the main post. These were seated on the permanent post brackets and the shore ends were anchored to the island span by inclined tension bars clamped to the main diagonal member.

The upper transverse struts were assembled between the tops of the pier posts and after the first two 40-ft. panels of the channel spans were erected, the derricks were removed from the tops of the travelers and the latter moved forward across the piers. The transverse bracing was then assembled between the pier posts and the derricks were re-erected on top of the travelers to continue the cantilever construction. This has now been completed six 40-ft. panels beyond each pier near a point where the contractors' calculations indicate that the cantilever stresses will relieve the end falsework towers of load from the superstructure. The bearings of the latter are carefully watched and as soon as they are seen to be free, the falsework will be removed from the ends to the center of the span and will be reerected on shore at both ends of the bridge where, with some additional bents and girders, it will serve for the support of the shore anchor arms.

The land between piers I and II on Manhattan Island and on both sides of them as far as 59th St. and 60th St., has been reserved for the contractors' use and is enclosed by a high fence. In it a gantry track 450 ft. long has been laid parallel with and about 85 ft. distant from the center line of the bridge. One of the gantries has been removed from Blackwell's Island and is established here where it is operated by electric current brought from the Island power plant through a submerged cable. The contractor has built a dock at the river end of this yard for unloading steel and other materials from lighters and has installed there one of the steel derricks with a 65-ton, 75-ft. boom. The stiff-legs are seated on shore foundations, but the foot of the mast is supported directly on a steel tower about 50 ft. high above low water level.

The water at this point is about 20 ft. deep at the center of the tower and the bottom was a steep rocky bank offering considerable difficulty for the construction of a foundation. An approximately horizontal footing was dredged in it and a pile cofferdam was built around it which, although not intended to be water-tight, protected it from the river current. The bottom was leveled by divers and a concrete footing was deposited under water. The foot of the tower column had previously been enclosed in a wooden mold, which was filled with concrete, forming an extended base or pedestal about 10 ft. square at the bottom thoroughly bonded with the steelwork. This was lowered to position by a derrick and seated on the fresh concrete of the footing so that its weight might bring it to uniform bearing before the concrete set. After the tower was in position the 65-ton derrick weighing altogether about 200 tons was delivered and set bodily in place on the tower and the other foundations by the Chapman Derrick & Wrecking Co.'s lighter Century.

The Feb. 9, 1907, report of the resident engineer showed that of the 27,000 tons of steel delivered at the site, 16,000 tons has already been erected. An average of about 1,000 rivets a day are now being driven with Cleveland and Pittsburg pneumatic hammers by twelve four-men gangs. The rivets are heated at present in coal furnaces which will later be replaced by oil furnaces. All of the rivets for the field connections are being driven, except those in the lower chords and stringers, which will not be driven until the cantilever erection is completed and the final stresses are developed in the members. The heavy horizontal box girders connecting the feet of the pier columns will be subjected to a considerable tensile stress due to the batter of the columns, and it has been computed that this should cause the girder to elongate about ⅜ of an inch. If this elongation were secured by pinning the rivet holes it would be very difficult to make it uniform and the final connections are, therefore, delayed until warm weather, which will cause sufficient expansion in the girder to make the rivet holes match. An average force of about 370 men are now employed on the erection and about one panel is assembled in two weeks by each of the travelers, an amount equivalent to about 1,300 tons of steel per month.

Unloading Derrick, Manhattan.

The bridge was designed and is being erected under the direction of the Department of Bridges of New York City. The Pennsylvania Steel Co. is the contractor for the manufacture and the erection of the superstructure.

The Improvement of Manila in accordance with the plans of Mr. D. H. Burnham was continued during the past year. The moat around the walled city and those branches of the Pasig River which were unsightly have been filled in, and will be parked when they dry out. The extension of the Luneta into the bay is also under way, but will not be completed for a number of years. The filling has been done by pumping mud from the bay and the total cost for the year ending Oct. 31, 1906, was $20,359.58. Some work has been done in dredging the arms of the river, in order to provide better channels. The dredging cost $0.25½ per cu. yd., a total of 8,444 cu. yd. having been removed.

Grade Correction in the Battery Tunnel.

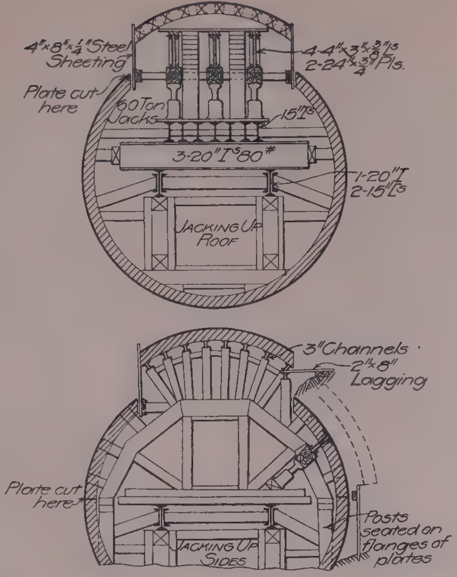
The correction of minor irregularities in the alignment of the approaches of the two single-track cast-iron tunnel tubes of the Rapid Transit railroad, between New York and Brooklyn, is advancing rapidly and the difficult and delicate work of raising the roof and depressing the invert piecemeal under a heavy pressure of fine, soft, wet material is being carried on satisfactorily and at an expense of less than one-fifth of a conservative estimate of that were the alternative shield method used. The work in progress will rectify the abrupt irregularities in grade without materially changing the general grade and will distribute the variations of level over longer distances, so that the relative position of the third rail will not be disturbed and so as to maintain the whole of the theoretical 8-in. clearance above the tops of the cars, an amount which was originally intended to allow for slight irregularities of construction.

Temporary Cantilever on Pier Post, Supporting Top Chord Eyebars.

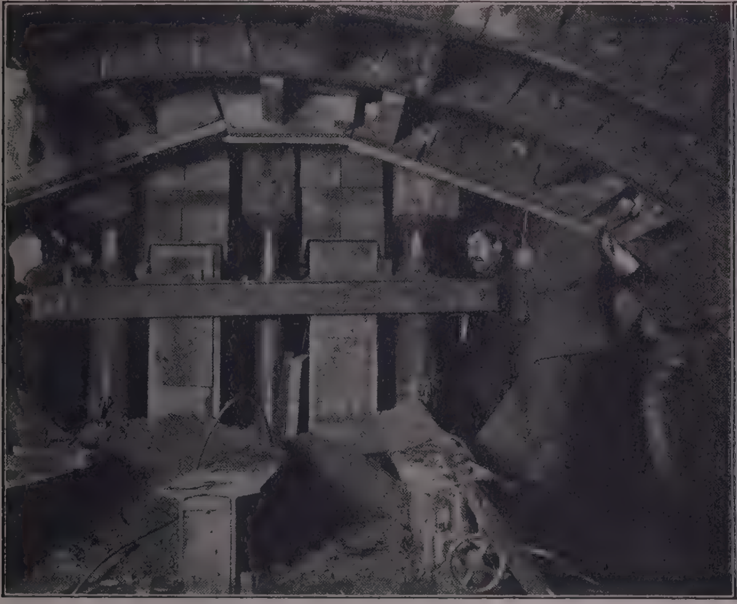
In the south tube under Joralemon St., about 8 lb. air pressure was maintained in a section 250 ft. long where the invert was depressed about 8 to 14 in. by means of special new segments of the lining which give the whole a slightly egg-shaped cross section. The lining is supported by a system of vertical posts, longitudinal girders and transverse and radial bracing, while the segments are removed as described in The Engineering Record of Sept. 29, 1906.

At the beginning of each section rectified, special rings are placed in the invert, with their flanges extended to engage those of the old lining and depress the webs several inches below the original position. In the section now under construction, the depression is made with two of these rings side by side which together carry the bottom of the invert to a depth about 19 in. greater than that of the original lining. The removal of the old lining is commenced by taking out the center segment of the invert, which usually has to be broken in small pieces. The bolts are removed from the adjacent segments in the same ring, and a tackle is attached to the lower end of it and to the overhead bracing. The lead line is operated by the capstan head of a hoisting engine driven by a Crocker-Wheeler motor, at the rate of 80 ft. per minute. This suffices to haul the lower end of the segment up to a horizontal position while the upper end remains engaged between adjacent rings. Fulcrum bolts are then put in the opening between the segments, and the segment is easily cantilevered out of position and the line from the hoisting engine, rove through snatch blocks, hauls it back into the completed tunnel and loads it on a car by which it is removed.

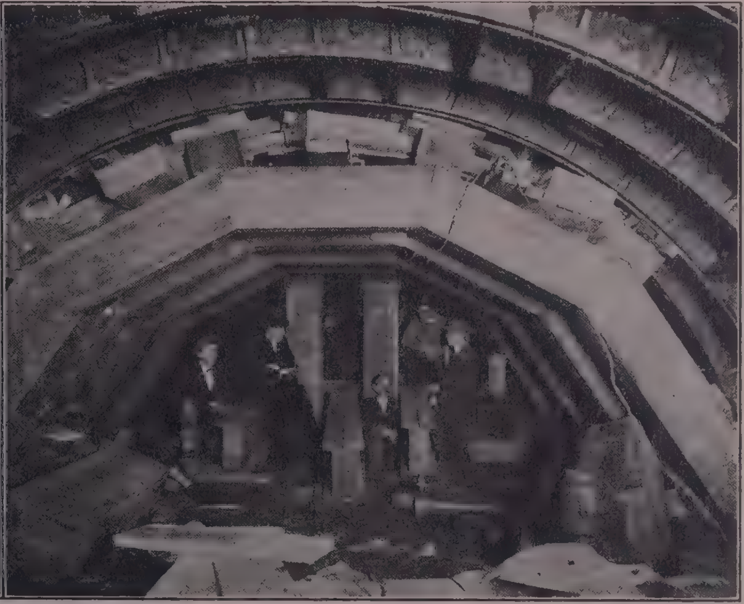
After the necessary segments in the first ring are removed, those in the next ring are much more easily removed by simply wedging and sledging, severe treatment which they endure remarkably well, often being extracted uninjured and transferred to the river headings to be used again in the lining there. The compressed air in the tunnel has a tendency, even under the very low pressure, to dry out the fine sand in the sides of the tunnel and make it difficult to hold. It is therefore artificially saturated by a constant spray. With this precaution, the sides of the earth hold up well when exposed by the removal of the lining segments, and no trouble is experienced either from caving in or from ground water, which at this point has a level of about 5 to 10 ft. above the invert.



Timbering and Jacking Roof Segments.



Jacking the Roof Segments.



Timbering the Roof Elevation.

This demonstrates that the external pressure below the skewback is very slight and that the soil is so good that the work could probably be carried on in safety without the underpinning and timbering which is used. The work, however, is so important, the conditions being such that even a slight settlement or delay would have serious consequences, that it is deemed wiser to continue the timbering, especially since it is all interchangeable and only requires a comparatively small amount, which is taken down in the rear and moved forward as the work advances.

At intervals of about 6 ft., the space between the new and old lining is completely filled with new segments and the tunnel bottom is closed to allow for grouting the bottom. After the grouting has set, the invert is again broken and the segments are removed, keeping a space of two rings open, which allows plenty of clearance for assembling one ring. Little difficulty is found even in entering the upper ends of the new rings, where they break joints with the old and project 2 ft. between the old segments with a clearance of 1/32 in. This work is being executed by a total force of about 20 men in each of the two shifts and progresses at an average speed of over 50 ft. per week.

Where it is necessary for about 100 ft. in each tube to elevate the crown of the lining, a steel beam platform is supported at about the height of the springing line on continuous lines of longitudinal steel girders and transverse bents consisting of a horizontal cap and two vertical posts, leaving a low-level passageway between them. The bolts are removed in transverse flanges of three crown segments of a ring, and in alternate rings the ends of the lower segments are cut through to make a continuous horizontal separation in the line of the staggered joints. Holes about 3 in. square are cut through the 1⅛-in. webs of the segments to allow the insertion of slice bars, which are thrust through them and worked in the earth and sand to loosen it. This enables it to flow towards the cavities formed by removing handfulls of sand, which are carefully measured and give a ratio of 3.05 loose sand to 2.97 void space, thus indicating a compression of the material. After "bleeding" the roof the old segments have been forced upwards by means of two sets of each of five special 60-ton hydraulic jacks made by the Watson-Stillman Co., and Richard Dudgeon, duplicates being provided to expedite the operations. The pistons are 4 in. in diameter with 30 in. stroke and are operated under a hydraulic pressure of 3,000 to 5,000 lb. by separate hand pumps each worked by one or two men.

A large percentage of the hydraulic jacks used in this work are operated by a pump recently designed by Mr. Richard Dudgeon. The upper part of the case is used as a reservoir for water or other liquid with which the pressure is transmitted to the jack through a copper pipe 9/16 in. inside diameter. The pump is operated by a detachable lever, inserted in the lever socket and actuating an interior cam which moves the piston up and down in its vertical guides.

The pistons have a 1¾-in. stroke and are integral with a single vertical rod. Both of them are normally in service for light or rapid work, the upper one being quickly thrown out of commission when it is necessary to increase the pressure. They are controlled by a series of three valves seated in a vertical line. When both pistons are in operation, their up stroke draws the liquid from the reservoir through both suction valves into both piston chambers. At the beginning of the down stroke, the suction valves are forced to their seats and the continued pressure opens the pressure valve against its spiral spring, not shown in the illustration, and forces the oil through it into the pressure chamber and thence through the outlet, not here shown, to the hydraulic jack.

When the load is heavier than can be moved with both pistons operating, the upper one is unloaded by holding the upper suction valve off its seat. This allows the liquid drawn into the upper piston chamber during the up stroke to flow back to the reservoir during the down stroke. Similarly if all three of the valves are unseated all of the liquid is allowed to flow around them from the pressure chamber to the reservoir and the ram in the jack is released. The upper suction valve is unseated by the valve rod which can be pushed down on it by a hand wheel, not here shown, at the upper end. After the rod is pushed down still farther it will successively unseat both of the lower valves and release the ram.

The jacks are seated on transverse beams and engage a special channel bar covering a cap bearing on wooden fillers packed closely between the flanges of the segments to act as cushions and distribute the pressure. The segments are displaced vertically in successive movements of about 1 to 2 in. each, which are made in 5 to 10 minutes actual jacking, care being taken to block up under the segments continually with wooden fillers and steel wedges as fast as the jacks are extended. Between the successive steps of jacking the ground above the segments is bled so as to diminish the resistance to the movement.

As each segment is raised, the edges on all four sides are protected by vertical steel poling plates 8 in. wide, ¼ in. thick and 48 in. long, which are driven to form a complete bulkhead, preventing the entrance of sand or other material. The lines of sheeting at the ends of the segment parallel to the axis of the tunnel are braced with rangers and remain permanently in position until the next step of the work is taken. Those on the rear side of the segment are removed as the latter reaches its required position. Those in front remaining until the next segment is jacked up and so on.

Originally the ground water line at this point was above the level of the crown, but during the construction of the tunnel, the drainage involved lowered it as much as 3 or 4 ft., so that its maximum level is now 2 or 3 ft. above the line where the new roof segments will join the old lining in the side walls just above the springing line. As the work advances, the side plates are jacked out singly after the roof has been braced with special timbering. Vertical sheeting will be driven outside the undisturbed segments, as shown, and the remainder of the segments to be replaced will be removed in alternate sections. It is hoped this work can be accomplished without resorting to air pressure, but in order to take every precaution in advance, provision has been made to supply pneumatic pressure immediately if necessary. When the flanges of the roof segments are found to be broken they are spliced by steel dogs ¾ in. in diameter and 12 in. long inserted in holes drilled to receive them and are then securely wedged in place by wooden fillers. After the top and side segments for the reconstructed section have been forced out beyond the limits of the new extended lining, the segments of the latter will be erected in position on the upper parts of the segment in the side walls of the present lining, thus leaving the old plates which have served as sheeting, just outside of them, the spaces between being filled with grout. One of the most tedious parts of the work is the drilling of so large a number of ¾ in. holes necessary to cut off the plates and to make the openings for the slicing bars, all of which is done by hand ratchet drills.

Since the preceding notes were written, the plan of operations has been modified at the suggestion of the sub-contractors, and the use of cast-iron segments in the roof has been abandoned in favor of concrete and brick work prepared with waterproof mortar.

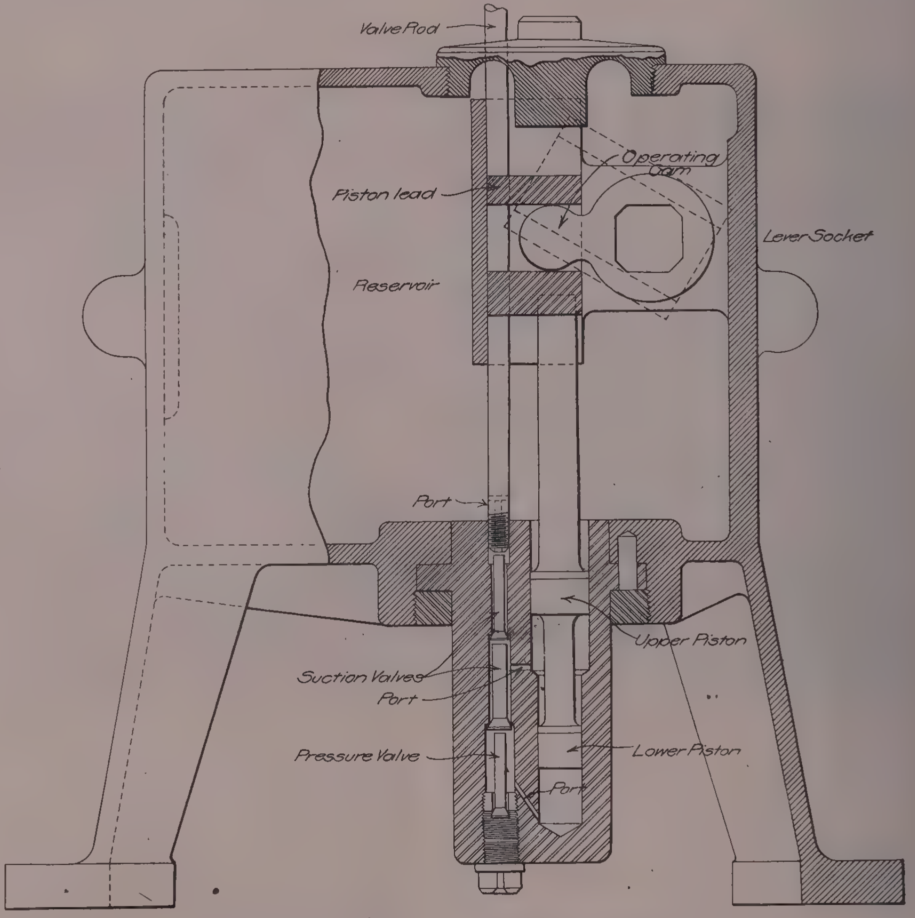
This work is being done under the direction of the Rapid Transit Railroad Commission, Mr. George S. Rice, chief engineer, and Frederick C. Noble, division engineer. The Rapid Transit Subway Construction Co. is the contractor, Mr. Geo. H. Pegram, chief engineer; Mr. Anton Schneider, division engineer, and Mr. F. D. Leffingwell, resident engineer. Cranford and McNamee have the sub-contract for this portion of the work of reconstructing and Mr. W. I. Johnson is their superintendent. Mr. Thos. McDermott is inspector in charge, and the work is being done under the direction of Mr. F. L. Cranford and Messrs. J. C. Meem and W. I. Aims, engineers.

A Boat-Loading Pier is used at Almeria, Spain, by the Alquife Mines & Railway Co., which has a total storage capacity of 10,000 tons of ore. It is a framed steel structure 360 ft. long, 62 ft high above the water level and 54 ft. wide. On the top are four parallel railroad tracks, each of which will accommodate twenty hopper-bottomed steel cars of 15 tons capacity. Under the tracks are two lines of hoppers, twenty hoppers on each side of the pier, each of which holds 250 tons when full. The material in the hoppers is discharged through chutes into vessels alongside the pier.

Recreation at the Isthmus.

Employees on the Panama Canal are being provided with club houses in most of the villages which the Canal Commission has built. They consist of a front building of two stories, connected with a rear building of one story. The former, which is 133x45 ft., contains a social parlor, a card room, a billiard and a writing room on the first floor, and an assembly hall 67x27 ft. on the second floor. The rear building, which is 100x28 ft., contains double bowling alleys 100 ft. long, a gymnasium 52 ft. long, shower baths and lockers. The Commission, in conjunction with the Y. M. C. A., will manage these buildings. Each club will select a board of directors from its own membership, but all clubs will be under the control of a general board selected by the Commission. A number of buildings are also to be erected for religious services, such buildings to be available for all denominations. In some places an additional story will be added to the latter buildings, to provide lodge rooms for the various orders and societies formed among the employees.

Tar-Spreading Machines are to compete for prizes offered by the Road Improvement Association, of England, which has arranged the competition to stimulate invention and to decide the best mechanical means of spreading tar on road surfaces so as to bind the road materials and prevent dust. The merits of the competing appliances will be judged entirely by the results of the tests, the chief considerations being the efficiency with which the tar penetrates the road and the cost of applying it. In the rules for the contest it is pointed out that, other things being equal, the advantage will lie with the machine which can move most rapidly, which consumes least tar, which requires no skilled attendance, which can use the tar cold as well as hot, which requires refilling least frequently, and other like points.



One Type of Pump Used for Hydraulic Jacking in Tunnel.

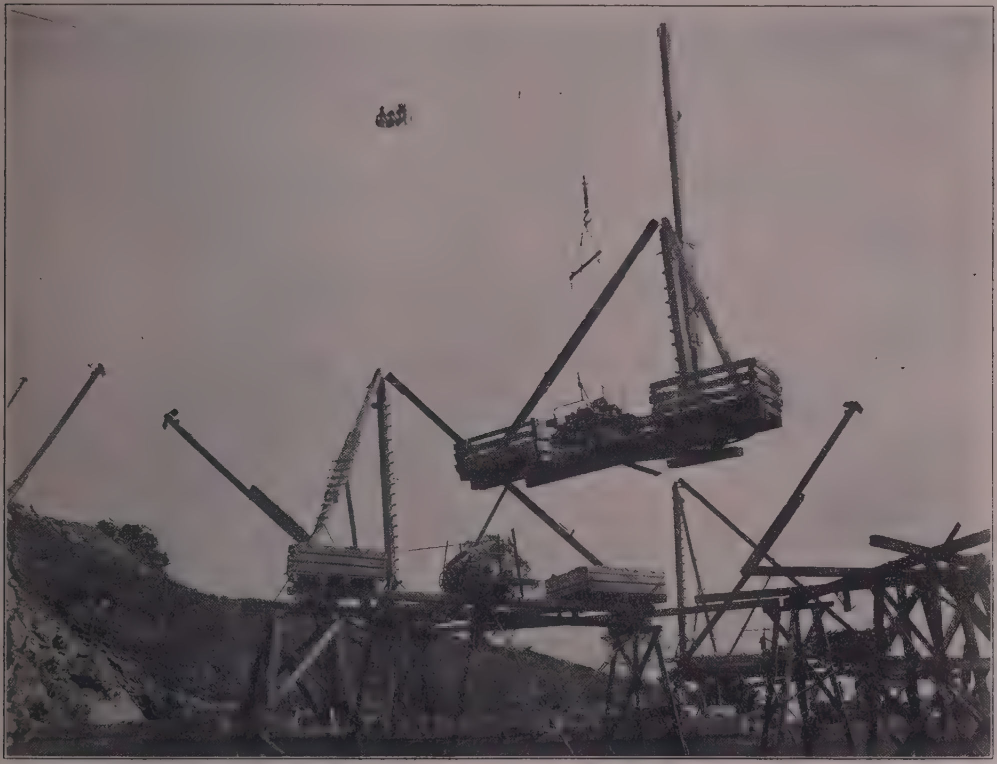
Moving a 15-Ton Derrick High Above the Ground.

The large molded concrete blocks, cyclopean stone and buckets of concrete used for the construction of the Cross River Dam at Katonah, N. Y., are handled by twelve stiff-leg derricks. These are arranged clear of the working surface on opposite sides of the great masonry wall which extends across the full width of the valley; this has now attained a height of over 50 ft. above the ground and will eventually attain a total height of 170 ft. above its foundations and a length of 900 ft., comprising 155,000 cu. yd. of masonry. Stone and concrete are delivered to the derricks by three cableways of about 1,300-ft. span, parallel with the axis of the dam, mounted on traveling towers which enable them to command the full width and length of the structure. The plant installed and methods of operation have been described in The Engineering Record of June 16, 1906 and January 5, 1907.

As the masonry rose above the bottom of the valley, the derricks were transferred from their original positions on the surface of the ground to timber towers built to receive them, and thus restore their full effective radius when it had been seriously impaired by the obstruction of the new masonry. The derricks are of the ordinary stiff-leg variety, having a tripod framework consisting of a vertical mast and two back-legs attached to a triangular frame. This frame is composed of longitudinal sills with platforms and cribwork bins to receive the stone ballast required to maintain the stability under loads of 10 or 12 tons at the extremities of the 60-ft. booms. Floors are also laid on the sills between the ballast boxes to receive the double-drum engines, but do not provide for boilers, because the machinery is operated by compressed air from the power plant.

As all of the derrick timbers and fittings are massive, the weight of the complete machine is large, and its frequent transfer from one elevation to a higher one would involve considerable expense and delay if accomplished by jacking, skidding or by the common method of dismantling the derrick and using the boom and mast successively as gin poles for hoisting each other. In this case, however, it was not necessary to adopt this method since two cableways of 15 tons and one of 18 tons capacity were installed at a sufficient height above the dam to lift the derricks to their required position and afford convenient opportunity for traversing them either longitudinally or transversely, so that they might also be shifted to any position in the length of the dam or transferred to the opposite face at pleasure.

In some cases the derricks were supported entirely on falsework towers, and in other cases one sill parallel to the axis of the dam was supported by heavy steel straps built into the downstream face of the masonry and projected from it to form hooks receiving the timbers, while the third corner of the framework was carried on a vertical tower clear of the dam masonry. In either case, after the masonry had attained a height sufficient to diminish the efficiency of the boom, an adjacent tower was built high enough to give full swing to the boom and when ready to receive the derrick the latter was hoisted bodily and transferred to its position on the new tower, ready to resume operations as soon as the anchorage was made secure and the compressed air connections made to the engine.



Moving a Derrick by Cableway at the Cross River Dam.

This was effected with great rapidity so that it was sometimes accomplished during the noon hour without putting the derrick out of service at all during working time. The accompanying photograph shows one of the derricks being hoisted with its engine complete by two cableways, one hitch being made with a bridle attachment to the back sill and the other, not visible in the photograph, being made to the foot of the mast. The fall lines are just at the right of the nearly vertical boom. The derrick is about to be seated on the top of the tower shown at the lower right hand corner of the picture.

The work is being done under the direction of Mr. Walter H. Sears, chief engineer of the Croton Aqueduct Commission, by MacArthur Bros., & Winston & Co.

A 48-in. Riveted Steel Pipe Line at Kansas City, Mo.

By C. K. Allen, Kansas City.

During 1903 and 1904 the city of Kansas City, Mo., constructed a riveted steel pipe line 48 in. in diameter and 17,163 ft. long from the Quindaro Pumping Station to the Kaw River. This line is used in connection wth an old 36-in. cast-iron pipe line which the new line parallels most of its length and crosses at three points. The 48-in. pipe is made in 7-ft. sections, each section being made of a sheet of ½-in. plate, the ends of which are joined with a double riveted lap joint. The successive sections of pipe are alternately 48 in. and 49 in. in inside diameter, and the encircling seams are lap jointed and single riveted, the lap being 3 in. Four 7-ft. sections were put together in the shop, so that every fourth encircling seam was field riveted.

About 500 lin. ft. of pipe, used under railroad tracks, is reinforced with longitudinal ribs and encircling hoops made up of plates and angles and riveted to the outside of the pipe. Each 7-ft. section of pipe has one hoop around its center, consisting of a 3 x 3 x ½-in. connecting angle to the outstanding leg of which is attached by its longer leg a 6 x 3½ x ½-in. stiffener angle whose ends are butted together and riveted to a 6 x 4 x ½-in. splice angle. Six longitudinal ribs are equally spaced about the circumference of the pipe. These consist of a 3 x 3 x ½-in. angle with a 3 x ½-in. filler plate under the attached leg. The connection angle of each hoop is cut in six separate segments, each of which is placed between two adjacent longitudinal ribs. The 6-in. leg of the larger hoop angle is notched to fit over the six ribs.

The pipe for its entire length is laid in the Missouri River bottom within 150 ft. of the foot of the river bluffs, but at some places nearly a mile from the river bank. In at least 80 per cent. of the trench fine silt and quicksand was encountered, which when wet flowed in the bottom of the trench. Moreover the trench top was in many places lower than the river's banks, making it impossible to keep the trench dry in rainy weather. The contractor intended to do most of his excavation with teams and scrapers and did do a large part of it by this method, but the Kaw River flood of June, 1903, flooded all but about 3,000 ft. of the line, much of which remained under water until the middle of July, completely saturating the soil. During August, September and October, the weather was very wet, greatly retarding the work.

The contractor lost one portion of trench about 2,000 ft. long twice from flooding of the trench, and had one section of pipe 1,500 ft. long flooded and broken in two after it had been riveted but not back filled. This was caused by a heavy rain that flooded the trench full in a few moments and lifted the pipe in the middle in a long vertical curve. After the trench had been drained, measurements showed a vertical rise of over two feet in the center of this section of pipe, held up by the dirt that had settled under it. The contractor set blocking under the floated pipe to the required grade and then lowered the pipe by undermining it. The rivets in this section were again all hammer tested and all loose ones were cut out and the caulking retouched, after which the pipe appeared from all tests to be as good as ever. The specifications had required all pipe to be left exposed in trench until after hydrostatic test, but after this occurrence it was back filled, except at bell holes, as fast as riveted.

Trouble was experienced at various places by the quicksand in the bottom of the trench rising and bringing the empty pipe up with it. This was arrested by loading the pipe as soon as it was coupled up. The contractor was furnished with grade stakes set 10 ft. from the center line 100 ft. apart. He first took out the upper portion of trench with teams, excavating within 1 ft. of grade with this method if the ground was dry enough. The bottom material was then taken out by hand and the trench carefully graded to a true surface, stakes being set every 27 ft. with their tops at the grade line, and the center line indicated on them with a tack. The grade was tried by stretching a line between these tacks, and the stakes were so set that they came exactly under the center of the field-riveted seams. The pipes were laid with heavy derricks moved and worked by hand, the crab being turned by two wagon wheels fastened on the end of the shaft, and these wheels also supported most of the weight of derrick during transportation. A laying gang ordinarily contained fourteen men and a foreman and the largest amount ever handled in a single day was twenty-six pipes. This record was reached only once, and then there was a gang bringing pipe to the derrick gang, so the latter did nothing but lower pipe into the trench and buckle up. A large part of the line is curved as it follows the railroad track at a constant distance from it. All pipe for curves was built with the required bevel in the joints and fitted the trench as well as straight pipe laid on a tangent, except where the men on one or two occasions attempted to lay a piece of pipe where it did not belong. It was found that one straight section would cause trouble in joints for 100 ft. if introduced into a 1 deg. curve.

At three separate points the new line crosses under the old 36-in. pipe and at each point the crossing was a long one, from 30 to 200 ft. of 36-in. pipe being exposed and supported on timbers in the trench. As this 36-in. pipe carried the entire supply of water for Kansas City, and as there is no storage of water in the city, this line had to be kept flowing at all times, since a break or blowing out of a joint would have caused a water famine. The work was handled so that not a single leak was started in the line, though in the Union Pacific Railway yards the work was very difficult to handle. The accompanying drawings will show the methods of timbering employed. The new pipe was carried under the old from one end, sections being added as fast as the new pipe moved a length of pipe ahead, and when the crossing was accomplished the pipe was forced back on to the finished pipe with jacks. Under the Chicago & Great Western R. R. crossing 108 ft. was carried into position in this way at one lift.

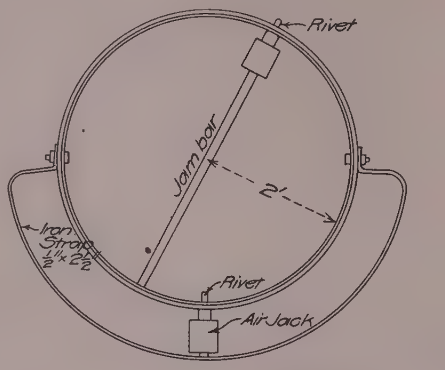
In driving the field seams, the contractors used a method of holdng on, for the lower half of the pipe, devised by the author, which was found to work much better than any one of several other devices which were tried and abandoned. This device was a strap of flat iron ½ x 2 in., bent to a semi-circle, with the ends turned in so that it could be bolted to the pipe, and would set the length of an air-jack dolly from the pipe, as shown in an accompanying sketch. All field rivets were driven with air hammers, the compressed air being supplied by an Ingersoll two-stage compressor and carried along the line in an iron pipe. Air was delivered to the hammers on the lower end of the line at a distance of a mile from the plant and all reaming and caulking was also done with compressed air. While the plant was able to handle the work and give fine results, maintaining over 100 lb. pressure at the extremities of the air line, the writer is of the opinion that a portable compressor plant and shorter air lines would have been a better arrangement for the contractor.

The material was all inspected at the shops, both in the mill and in the boiler factory, and was dipped at the shops in a bath of hot Trinidad asphalt. It was shipped four pipes to the car and delivered by the railroad alongside of the trench. All pipes were inspected as they were unloaded from the cars and every field rivet was hammer tested by an inspector who had nothing else to do, while another man inspected the caulking and did not allow the men to start caulking on any seam until all the rivets in that seam had been approved. As soon as the seams were caulked the inspector of caulking notified the inspector of painting and back filling, who saw that the men cleaned each joint thoroughly with wire brushes and then gave it a heavy coating of hot asphalt paint. When the weather was very cold, it was found impossible to make this field coat adhere properly to the iron, but when the temperature was above freezing not much trouble was experienced from this cause. The inspectors kept a daily log of the number of men and teams employed on each part of the work and once every week they turned in their reports to the engineer in charge, who tabulated them and made additions from his own notes. This enabled the city officials at any time to tell at a glance just how large a force was working on any day, and also where they were working and the amount of work accomplished each day. While the collecting and compiling of this data cost the city something, it has been repaid many fold since the completion of the line.

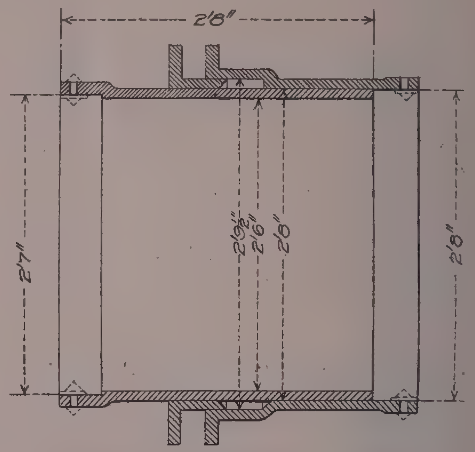
The construction of the line and the difficulties encountered have led the writer to draw the following conclusions: Where it is desired to stiffen steel pipe against collapse under railroad tracks and smilar places, it is cheaper and better to reinforce the pipe with concrete around it, if necessary, this concrete to be placed after the pipe is in place and otherwise completed. The stiffened pipe is much more difficult to manufacture than the plain pipe, and when stiffening is used all holes should be sub-punched and then reamed, if the pipe is to be tight under heavy pressure. In the field joints we found that we could drive tight rivets in the stiffened pipe with the percussion air hammers by using care in reaming holes and plugging the rivets and having the rivets white hot before attempting to drive them. When tested under 130 lb. hydraulic pressure the field work was invariably found tight, even in the stiffened pipe, while the shop work on the stiffened pipe leaked badly. The field seams should be the most difficult to make tight as the splice plates require that some of the rivets be driven through four thicknesses of plates, making a grip of nearly 2 in., yet they were driven perfectly tight with the Monarch air hammer. In wet or low ground, where the trench is in danger of flooding suddenly, the pipe should either be filled or weighted to prevent it from floating out of line and grade. Inspection at the shops should be very close, especially of the riveting. If a pipe of the size and strength of this line does not begin to leak under 30 lb. pressure there will be no leak of consequence under 130 lb.

During the summer of 1904 two 30-in. steel lines were laid on the Chicago & Great Western Ry. single-track bridge across the Kaw River, by Mr. A. M. Blodgett under a contract with the city. These pipes were connected with the Cotter line on the left bank of the Kaw and with the existing city lines, on the right bank, by the Water Department.

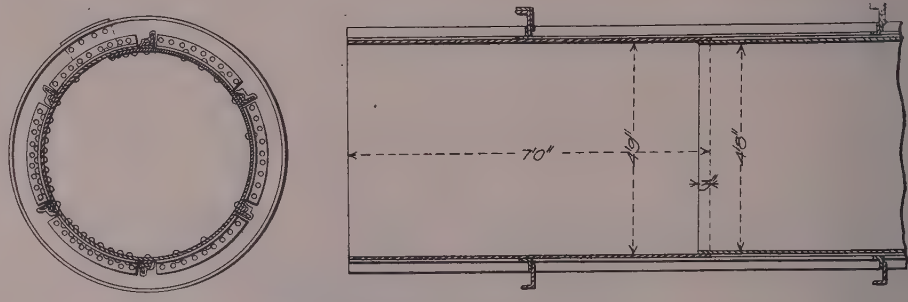
The bridge consists of three through truss spans each about 200 ft. long, and two through plate-girder spans, each about 82 ft. long. The pipes are carried, one on each side of the bridge, outside the trusses and girders, and are supported, a little more than 30 in. below the base of the rail, on wooden seats resting on the ends of two-piece wooden stringers 16 in. square. These stringers are supported at 25-ft. and 13⅓-ft. intervals on the trusses and girders respectively. They are 26 ft. 6 in. long and each is hung under the steel work,



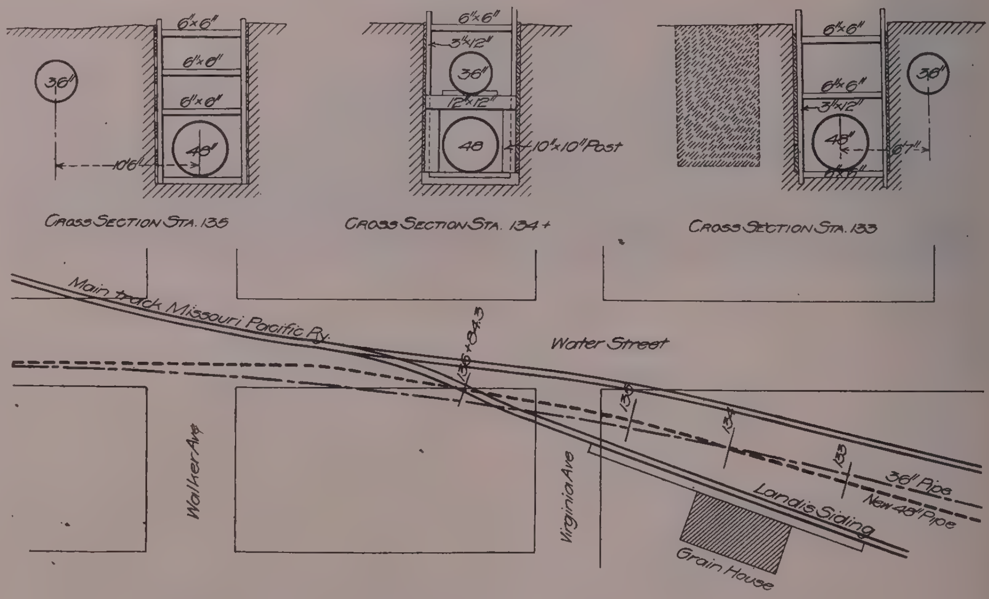
Device Used in Field Riveting.



Section of Expansion Joint.



Sections of the Reinforced Pipe.



Timbering Used Where the 36 in. and 48 in Pipes Cross.

to which it is attached with stirrups and rods. In a few days the new Kaw River tunnel will be put into service and these lines will then be taken down, as the city will have no further use for them on the bridge. In these lines were four expansion joints, a section of one of which is shown in an accompanying illustration. These joints have all moved from 1½ to 3 in. since the pipes were put in service, but they are perfectly tight now and never cause any trouble.

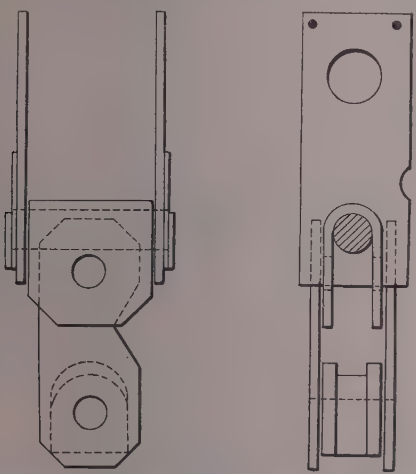
The detailing of the pipe and the drawing of the specifications was done by Waddell & Hedrick, consulting engineers, of Kansas City. All field and construction work was under the immediate direction of the author. The contract was let to Mr. Jas. Cotter in May, 1903, at $10.90 per lin. ft. for plain pipe and $14.75 per lin. ft. for reinforced pipe, he to furnish all labor and material. Shortly before the work was finished Mr. Cotter died and his creditors had the courts appoint a receiver, who completed the contract and then brought suit against the city for an amount of extras that the city thought exorbitant. The court has not yet rendered a decision in his case, but the city was enabled to make a much better showing in the case by having the data collected on the work by the inspectors and the engineer in charge.

The Erection of the South Anchor Arm of the Quebec Bridge.

A detailed description of the south anchor arms of the Quebec bridge was printed in this journal on Dec. 1, 1906, and the enormous traveler used on the work was described on Feb. 23.

Immediately after the completion of a portion of the falsework for the anchor arm, the erection of this traveler was commenced on it at the shore end. The lower truss and the lower sections of the vertical posts were assembled by two stiff-leg derricks on the falsework and were temporarily braced by timber struts and guys to keep them stable until the completion of the erection. A 65x56-ft. horizontal skeleton platform composed of light beams and girders made special for this purpose was assembled on the falsework inside the traveler, and on it were mounted four stiff-leg derricks, one at each corner.

Vertical brackets with double steel webs were bolted to the upper ends of the four inside vertical posts of the traveler carrying manila rope 4-part tackles led from the corners of the platform to the hoisting engines. These ropes being wound on the drums lifted the platform and derricks to the top of the first section of the tower and maintained them there until another set of solid-web steel brackets were bolted to the inner faces of the inside posts and formed lugs supporting the platform.

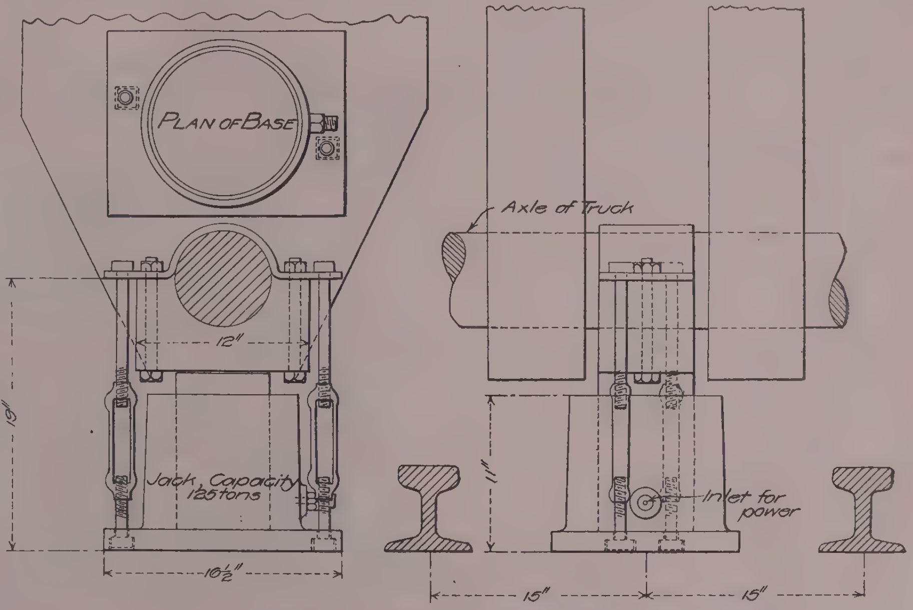


Connection of 55-Ton Tackle to Jigger Beam.

The hoisting tackles and brackets were then removed and the second sections of the traveler tower posts were erected from the platform. After the bracing was assembled to them and temporary transverse struts and guys had been provided to insure the stability of the incompleted tower, the hoisting apparatus was attached to the tops of the vertical posts, the platform lifted up to them, the supporting brackets transferred to new positions under the platform, the hoisting apparatus removed, another section of the tower built and so on until the tower portion of the traveler was completed and the girders and diagonal bracing in the top assembled giving it independent stability. The upper cantilever trusses were erected by two of the stiff-leg derricks moved to the upper transverse girders for that purpose, and the erection platform and derricks and temporary bracing removed.

Equipment of Traveler.—The traveler is equipped with eight 55-ton steel cable tackles, eight 25-ton and twelve 10-ton manila tackles and eight 17-ton movable manila tackles suspended from the jigger beams at the top of the tower and in the upper cantilever truss and has besides numerous whip lines and small tackles for handling light materials and guiding heavy loads. The tackles are operated by four special electric hoisting engines seated on the working platforms in the foot of the tower and in the rear extension where they serve as partial counter-weights for the loads suspended from the front overhang. Part of the tackles are located in the planes of the trusses and part of them are eccentric to provide for lifting the members from the service tracks and fleeting them into position.

All of the heavy tackles are connected directly to the stringer and jigger beams, but some of the smaller ones are supported directly from a system of wooden longitudinal and transverse beams laid across the top flanges of the jigger beams and providing for the location of the tackles at points eccentric from the latter. Pairs of 8x16-in. beams about 3 in. apart are generally used and have short transverse beams seated on top of them in the required position and bored to receive hooks or clevices which pass between the main beams and connect with the tackles below them. Loads of 22 tons are carried by transverse beams supported on double pairs of 8x16-in. beams.



Hydraulic Jack for Lifting Traveler.

Great care has been taken to arrange the tackles so that the hoisting lines can be led across the top of the traveler to the sides and all brought down to the hoisting engines adjacent to the vertical posts, thus leaving full clearance through and under the traveler for erection operations and the delivery of members. This arrangement involved a rather complicated system of lead lines that are carried around horizontal sheaves attached to pairs of 8x16-in. timbers laid flat-wise and securely bolted to the top of the traveler. A complete diagram was made, showing the arrangement of all timber and rigging and carefully marked with different conventions to indicate points where wire or manila rope tackles or snatch blocks might be attached and showing the loads permissible for each.

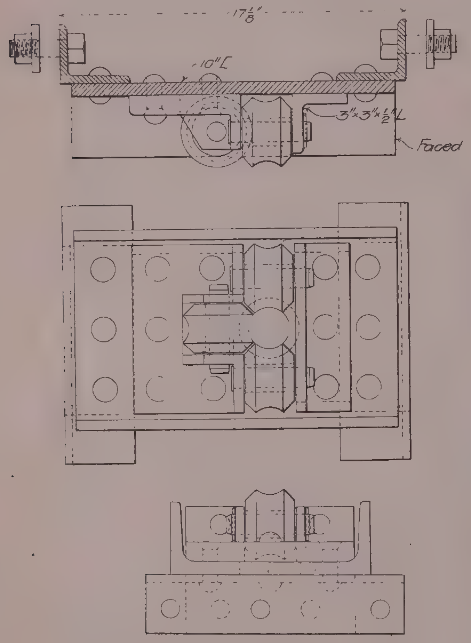
A table was also given enumerating the estimated weights of the blocks and attachments as follows: For a 22-ton manila tackle 2,974 lb. in one position and 3,810 in another varying on account of the different bearings provided for it. For a 17-ton manila tackle 2,974 lb., for a 10-ton manila tackle 1,544 lb., for an 8-ton manila tackle 940 lb. and for a 5-ton manila tackle 542 lb. The wire rope tackles and attachments complete weigh from 7,600 to 12,000 lb. The girders from which the 55-ton wire rope tackles are suspended have double webs which are bored on the center line for 5 13/16-in. pins. These pins engage between the webs, the upper ends of pairs of vertical plates or links 11 in. wide and 1 in. thick. These project below the bottom flange of the girder and their lower ends engage 4-in. pins clear of the girder. These pins receive U-shaped hangers made of 12½x1-in. plate and bored for pins 3 7/16 in. thick which are transverse to the link pins and clear them. They in turn receive pairs of vertical 10x1⅛-in. plates 25 in. long assembled outside the U-plates and bored at the lower end for 3 5/16-in. pins provided with cast-iron saddles to act as bushings for the shackles on the upper blocks of the tackles.

The hoisting lines of the 55-ton tackles are led over 23½-in. cast steel guide sheaves weighing 176 lb. each arranged inside of the double webs of the jigger beams which are reinforced to give sufficient bearing for their 2-in. pins.

Besides running through guide sheaves, the wire ropes from the 55-ton hoisting tackle leads are guided at various places in the top of the traveler on small steel friction rollers set in plates provided with connections by which they can be bolted to the under sides of the stringers or other members of the traveler as desired. The rollers, about 3¾ in. in diameter, are turned from solid steel bars and provided with phosphor bronze metaline bushings. Their fixed pins are secured by cotters in the outstanding flanges of the angles riveted to the webs of the channels that support them. These rollers are arranged at right angles to each other with their adjacent ends beveled to make a miter joint and to provide for ropes leading in different directions and passing through a central hole in the channel.

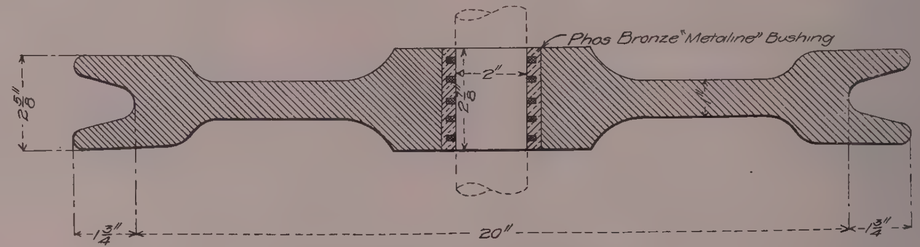
The sheaves have 2 7/16-in. bushings made by The North American Metaline Co., of a special mixture of gun metal bronze fitted with soft lubricating metaline plugs. It was designed expressly for the severe duty required in making long hoists of very heavy loads. It was assumed that a bearing pressure of 5,000 lb. per square inch might be developed for a sheave running at considerable velocity for about 15 minutes while hoisting a load 200 ft. high. Ordinary hoisting blocks develop bearing pressures on the bushings of from 9,000 to 10,000 lb. per square inch and as 2,500 lb. per square inch is considered about the limit for oil lubricated machine bearings, an investigation of sheave bearings was made before the sheaves and blocks were designed.

A special testing device was constructed under the direction of Mr. John Sterling Deans, chief engineer, and was fitted with a 2-in. motor-driven shaft running in three bearings having metalined bushings 1½ in. long and 2¾ in. in outside diameter. The shaft was loaded with pig iron and test records were made of the condition of the middle bearing as follows: Pressure per square inch 1,867 lb., r.p.m., 34, duration of test 20 min., condition of bearing slightly warm. Pressure 4,000 lb., 34 revolutions, 22 min., condition good, about as warm as could be handled. Pressure 5,000 lb., 36 revolutions, 20 min., not injured, too hot to handle. Pressure 8,000 lb., 36 revolutions, 22 min., quite hot but apparently not hurt. Pressure 8,000 lb., 38 revolutions, 30 min., very hot and smoky, apparently uninjured. The intermissions between tests were not long enough in all cases to entirely cool the bearings. These tests were considered much more severe than the duty of the bearings for hoisting sheaves. In the former about 9½ sq. in. of revolving shaft contact was lubricated by 3 sq. in. of metalined bearing surface. In the latter case these quantities are reversed and 3 sq. in. of fixed shaft contact is lubricated by about 9½ sq. in. of revolving metalined surface.

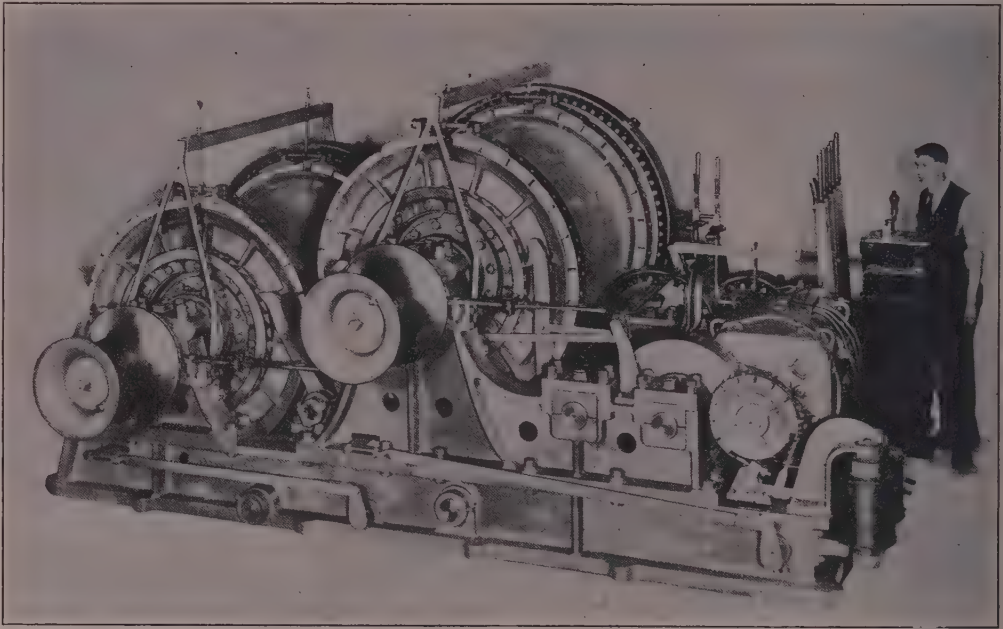


Guide Sheaves for Lead Lines in Top of Traveler.

Besides the heavy tackles already mentioned, many whip lines and lighter tackles are used so that the total equipment of the traveler comprises about 60 sets of lines aggregating about 7½ miles of ⅞-in. plough steel wire rope and 15 miles of 1½-in. manila rope, 3 miles of 2-in. and 6 miles of 1¾-in. manila rope. An approximately equal quantity is carried in storage at the site for miscellaneous uses and for renewals. All of the manila rope is made from selected fibre by The Plymouth Cordage Co., Plymouth, Mass., and purchased through Uhler & English, Philadelphia. The thirteen part 55-ton tackles were designed to effect as great a multiplication of power as is advantageous considering the great loss by friction due to a large number of parts. It was computed that in such a tackle there is a loss of 57 per cent. due to friction. That the loss is very great, is demonstrated by the fact that on one occasion a 23-ton load was insufficient to overhaul one of the 55-ton tackles and it was necessary to attach another tackle to the lower block to pull it down.



Sheave for 55-Ton Tackle.



Electric Hoisting Engine Used on Traveler.

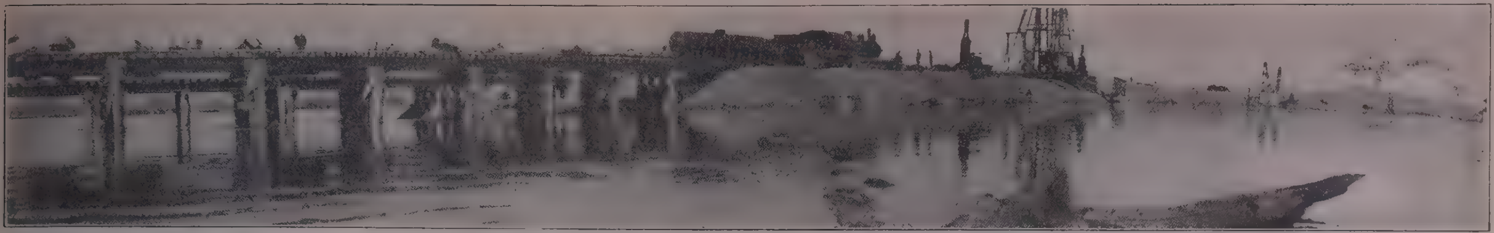
All of the tackles are operated by the four special Lidgerwood hoisting engines seated on the lower platform of the traveler. Each engine is driven by a 115-h.-p. 500-volt General Electric motor with an R 9 controller. It weighs about 25 tons and has two shafts each equipped with a drum 18 in. in diameter and 48 in. long and with two spools all running free on it and operated by standard square clutches which enable any one to be run independently of the others. The shafts are mounted on separate standards on a very rigid one-piece bed plate and all the operating levers are grouped together so that the engine can be controlled by a single man with assistants at the spools. The engine is built with two sets of gears 38.78 to 1 and 16.47 to 1, so that it can hoist 3,300 lb. 100 ft. per minute on a single line or 15,000 lb. 150 ft. per minute on a single line. It is equipped with a solenoid brake shown at the right hand in the foreground of the picture, which is designed so that any interruption of the electric current will automatically set a brake on the armature shaft and thus prevent the load from falling. The pawls can be operated independently by levers controlled at the lever stand. The drums have a capacity of 4,500 ft. of ⅞-in. wire cable all of which is required for one of the 13-part tackles. They are fitted with V-band brakes and special provision is made to prevent the clutches from being accidentally disengaged. For hoisting the heaviest loads of 105 tons, two engines have been used together and the load has been lifted at a speed of 15 ft. per minute.

All hoisting operations are directed by the foreman in the lower part of the traveler who waves his arms for signals to the engine man or an assistant who transmits them to him. The drums are devoted to the operation of the 13-part 55-ton tackles and signals referring to them are designated by the signaler tapping his own head. Other gestures are used to designate other tackles. The heaviest loads lifted at one time have been the simultaneous hoisting of two 70-ton sets of top chord eyebars, which with their attachments and tackles makes a total load of at least 170 tons. Care is taken not to lower more than one of the main members in either truss at the same time from the traveler overhang. This precaution reduces the danger of subjecting the traveler to indefinite loads in making connections, and is considered to be a very important point in erection.

An important item of the traveler equipment is the set of 150-ton hydraulic jacks for lifting the traveler to remove the load from its wheels. The jacks are of standard construction made by the Watson-Stillman Co., but are provided with special cap plates fitted with concave bearings and loop straps to engage the axles of the trusses. The caps are attached to the bases of the jacks by vertical rods adjustable with long turnbuckles so that when the traveler is moved, the jacks can be carried with it suspended from the trucks. When in service these turnbuckles are, of course, extended so that they do not interfere with the operation of the plungers. The jacks used for lifting the chords on the camber blocking were made by the same manufacturers and have capacities of 300 tons and of 500 tons. They are of standard construction and are 20 in. in diameter and 18 in. in height with a stroke of 6 in.

Mr. E. A. Hoare is the chief engineer and Mr. Theodore Cooper consulting engineer of the bridge company. The contractor for the steel work and the superstructure is The Phoenix Bridge Co., Mr. John Sterling Deans, chief engineer, and Mr. A. B. Milliken, superintendent of erection.

The Miner's Inch as a unit for measuring water is likely to be misleading unless it is specified what State rule governs the measurement. According to Mr. Samuel H. Lea, State engineer of South Dakota, 1 cu. ft. per second is equivalent to 50 miner's inches in California and South Dakota, 40 in Arizona and 38.4 in Colorado.

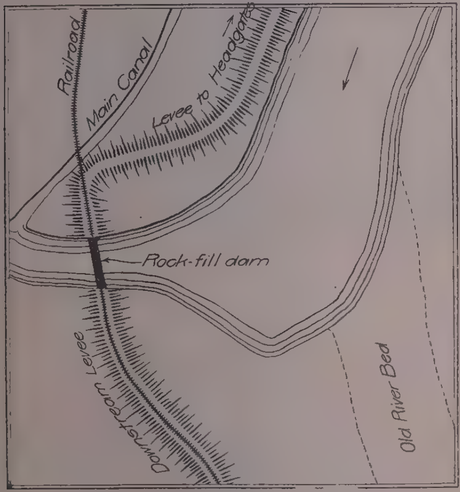


View of Trestle Across the Recent Break in the Bank of the Colorado River.

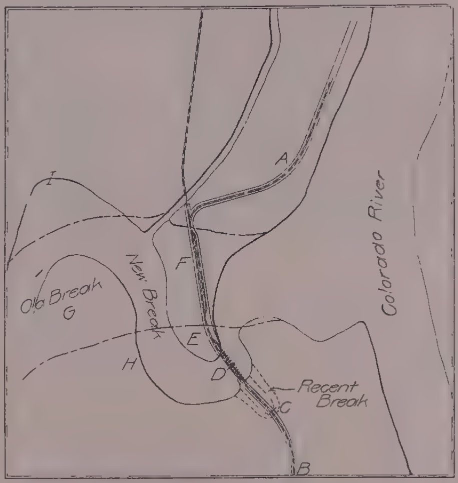
CLOSING THE NEW BREAK IN THE COLORADO RIVER.

By H. T. Cory, M. Am. Soc. M. E., General Manager, California Development Co.

On Nov. 4, 1906, the break in the Colorado River through which all of its flow had been running to the Salton Sea was technically closed, meaning thereby that the rock-fill dam which was thrown across the break was raised at all points above the water surface. Of course quite a little leakage through the dam was taking place and this was checked by unloading gravel and clay over the dam and by pumping a banquette on the upstream side with a suction dredge. On Nov. 15, all of this seepage water was cut off and the dam raised as rapidly as possible with clay and gravel, mixed in about equal portions, that it might be high enough to be safe against the highest water which might be expected in the Colorado River. Work was in progress along the levees connecting the north end of the dam with the reinforced concrete and steel headgate, about 3½ miles above, which is founded on a rocky point which juts out to within about 1,700 ft. of the west bank of the Colorado River; and from the south end of the dam along the west bank of the Colorado River for a distance of 8 miles.



Conditions on Nov. 4, 1906.



Location of Recent Break.

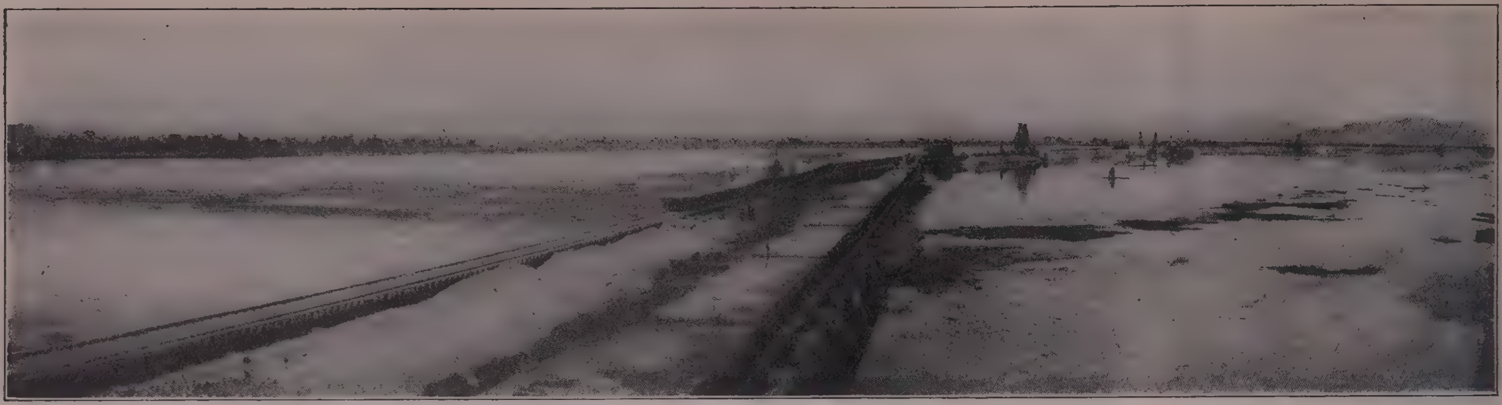
The levees were practically completed north of the dam on Dec. 5, and south of the dam a force of 350 head of stock was working in three places; one contractor working with about one-third of the total force was just finishing the section extending from the south end of the dam to station 114, and two more contractors were fairly well advanced with 2½ miles more extending from that point south. The dam was by no means completed nor was the levee system.

A sudden flood due to a rainfall extending over the watersheds of the Gila, Salt and Verde Rivers reached Yuma late in the afternoon of Dec. 7 and four hours later the water began to rise very rapidly at the Lower Heading, as the location of the break is generally called. The water rose very rapidly, as is usual with such floods, and the height of the water in front of the dam, which had gradually fallen from El. 113 ft. above sea level on Nov. 4 to El. 110 ft. on Dec. 7, reached El. 116.4 by 5 o'clock the following morning. In many places the water began to "blow up" back of the levees in the vicinity of the dam, and a large force of men which was at work finishing the dam and had been called out in anticipation of trouble, found it necessary to distribute its efforts over about a mile of levee and dam, or that portion from A to B in the second figure. Three "blow ups" very close together about 2,500 ft. south of the end of the dam seemed no more dangerous than many others and were apparently checked at 12:30 a. m., Dec. 8. About three o'clock, however, they again broke forth suddenly and more dangerously than before and soon filled the borrow pits which were on the land side and ran off over the ground in a westerly direction following the slope of the land, which is away from the river bank. Shortly after the ridges in the borrow pit, which were but little above the original land surface, were overtopped and the water ran for a time in both directions, but the fall of the land being toward the dam into the channel of the old break at the end of the dam, in a very short time the entire flow through the break was in that direction. The soil erodes almost like sugar, and by 5.30 a. m. it was evident that unless the river should fall before the cutting back should reach the old break on the river side of the levees, nothing could prevent a repetition of the original break. The river did fall rapidly, but not sufficiently to prevent the catastrophe, and by noon of the next day the greater portion of the Colorado River was again on its way to Salton Sea.

Referring again to the second figure, the water did not reach the river toe of the levee system, practically speaking, except between points A and B. The reason for this lies in the fact that the levees are, generally speaking, not more than 300 to 700 ft. distant from the river bank and the ground slopes away from the bank very rapidly, the average being about one foot in the first 200 ft. and another foot in the next 400 ft. The river itself has a fall of 1.2 ft. to the mile at this point, so that the greatest depth of water against the levees came at about the point marked D. The three "blow-ups" which developed into breaks, were at the point marked C, and each caused a break about 20 ft. long with a distance between each of about 60 ft., all occurring almost simultaneously.

The water rushed out very much as shown in the figure, rapidly cutting away a bend which in turn caused a rebound of the water which cut

View Showing the River Conditions While Re airing Trestles Across the Break in the Bank.



View Showing by the Line of Drift the Course of the Current through the Break.

away the back of the levee at the point marked D, and then continued along the levee in the borrow pit to the end of the dam, eroding the downstream slope of both levee and dam. In about eight hours the cutting action on the downstream toe at D had worn away so much of the levee that it failed at this point, and because of the greater depth there the water cut back through this new break more rapidly than elsewhere.

When this channel cut back into the pond above the dam made by the bank of the old break the proportion of the water going toward the Salton Sea increased very suddenly—so suddenly in fact that the steamer "Searchlight," which had gone down the old channel of the Colorado River a couple of miles was unable to return and was left aground. When the discharge of the river fell to 15,000 second-feet there was not more than 100 second-feet going down the old channel.

The new break thus formed a very tortuous channel and the cutting on the outside of the various curves eroded away material with marvelous rapidity. The force of the current coming over the broad shallow reach exactly opposite the dam gathered together in a very narrow and swift current, cutting away the little strip of original soil lying between the break and the levee just south of the dam, and it was soon evident that heroic efforts would be necessary to prevent cutting through the dam itself at its south end. Gravel and rock were dumped at this point as a blanket to protect against such erosion and the efforts were successful. Just below the levee the bank eroded away from the Colorado River and threw up a sand bar between itself and the levee at E and filled up at F the very deep hole which was below the rock-fill portion of the dam and made a sand bar in the portion G in the channel of the old break. The situation on Dec. 15 was about as given in the figure, with the banks caving in rapidly at H and I.

In view of the experience in closing the break by means of a rock-fill dam there was little doubt but that closing the new break was a matter of money and equipment very largely, with the difficulty that at this season of the year sudden floods are very apt to occur in the Colorado which would make the task far less certain of a satisfactory result. The real trouble, however, was seen to be not the closing of the break, but the making of a levee system along the Colorado River bank which would be unquestionably safe. The very large expenditure which was seen to be necessary was felt to be too great to be borne by the financial interests which had closed the former break and the matter was brought to the attention of the United States and Mexican Governments, with results which were doubtless too widely published to justify repeating here.

On Dec. 20 instructions were received to begin work closing the break, plans for which had been thoroughly matured in the meantime. Material was rushed forward and two lines of trestle started across the new break, as shown in the figure. These trestles were intended to be 50 ft. apart, center to center, and each consisted of four pile bents 15 ft. center to center, with two 8x17-in. stringers as decking. The lower trestle was pushed to the exclusion of the second or upper trestle because it was deemed possible that material could not be gotten on the ground fast enough to drive the two simultaneously.

The lower trestle was practically completed and rock would have been dumped therefrom on Jan. 1 but for two sources of delay. The first of these was lack of piling which delayed the work about 48 hours and the next was two days and a night of cold drizzling rain which found the camp unfinished to such an extent that the men were thoroughly wet and chilled and so very uncomfortable that they flatly refused to work in the rain on the second day. In consequence another flood from the Gila, the Salt and the Verde River basins came up before any rock could be dumped from this trestle and fifteen bents at its north end were washed away together with about 250 ft. of the end of the levee. When this flood went down work was immediately begun repairing this damage, and again a flood came, tearing away several bents in the center and thus changing the channel to the center of the trestle. The water here was about 35 ft. deep, and the current was very swift and struck the trestle at an angle of about 40 degrees. The Colorado River in times of flood carries an immense amount of drift and this circumstance contributed to make the task of driving the piling in the break of the trestle one of exceedingly great difficulty. Nevertheless the trestle was again finished practically when another flood occurred, coming from the same watersheds and carried away several more bents. It soon passed and these were repaired as soon as possible, 90-ft. piling being used, the cut-off being 10 ft. above the water surface. Finally on Jan. 27, at 4 o'clock in the afternoon, the first trainload of rock was pushed out upon this patched-up trestle and within 48 hours about 12,000 cu. yd. of rock were unloaded therefrom into the bed of the river. On Feb. 2 another rise occurred in the river, but sufficient rock had been gotten into place to hold the first trestle and give a difference in head above and below it of 4.4 ft., so that but twelve piles were washed away from the second trestle, although it had not been possible to entirely finish it and dump any rock from it. The drift piled up against both trestles to an alarming extent, but although it pushed both trestles out of line pretty badly in a couple of places they were not very seriously damaged. Repair work was started on the upper trestle the moment the water in the river started to go down and although the difficulty of driving very long piling in 35 ft. of water with a swift current and through a mass of accumulated drift was very great, the second trestle was completed on Feb. 4 and the dumping of rock and gravel from it started at 4 o'clock in the afternoon. On Feb. 4 the discharge in the Colorado River had dropped to about 25,000 second-feet and sufficient material

Surface Slope of Water when Trestle had a Head of 4 Feet.

had been dumped from the upper trestle to insure its being made safe against a reasonable flood within the time in which one can reach the Lower Heading from the watersheds which alone can produce such a rise in the river.

Some interesting data will be obtained as to the amount of rock which will be lost in building a rock-fill dam with and without the use of brush mattresses. The dam which was completed on Nov. 4 was founded upon a brush mattress very substantially woven and extending up and down stream a hundred feet in width. The rock-fill dam now under construction is being built without such a mattress. Some other interesting features of this rock-fill dam will be the great speed with which material is being put into it. Complete records were kept with the first dam and are now being kept regarding the present dam, and the comparisons between the two will be carefully worked out and published for the interest of the profession as soon as possible after this work shall have been completed.

View of Some of the Repaired Trestle Bents.

There are three possible, almost probable, sources of failure which may overtake the present work. The first is the possibility that a rock-fill dam cannot be built in a silt formation, which erodes almost as easily as sugar, without any foundation whatever. This is exactly what is being attempted and in the light of experience here it is not believed there will be much trouble from this source. The second is that both trestles are patched-up weak affairs with bents badly spaced and piles out of line and out of plumb. The pictures will give an idea of the extent to which the alignment was changed and forced downstream in order to utilize to the utmost such portion of the bents which were damaged but not entirely taken away, as was at all safe, in order to begin unloading rock at the earliest possible moment. The third source of possible failure is the possibility of a very great flood coming down the Colorado River and entirely overtopping the trestles or the dam to be, after the water shall have been forced down the old channel in its entirety but the dam itself not raised to its final height. The cut-off of the piling is at El. 114 ft. while the top of the dam will be at El. 124 ft., and this latter figure is believed to be at least 4 ft. above the highest high-water mark which will ever occur in the Colorado River.

Two steam shovels are loading rock into steel side dump cars at a quarry developed primarily for use in making the closure last summer and from this source about 4,000 cu. yd. of material is received daily. Another thousand yards of rock is being received each 24 hours from several sources, one being the Casa Blanca quarry on the Santa Fe line near Riverside, Cal.; another from the Bly quarry on the San Pedro, Los Angeles & Salt Lake R. R., near Colton, Cal.; another from the Declez quarry on the Southern Pacific R. R., also near Colton, all of these being about 160 miles west of Hanlon Junction, the point on the Southern Pacific R. R. from which the spur to the Lower Heading starts. The fourth outside quarry is at Tacna, 40 miles east of Yuma, and still another is at Patagonia, 380 miles east of Yuma on the branch line toward Guaymas. From these five quarries large rock is obtained, many weighing as much as five and six tons each.

At the present writing there are now working on the reconstruction and extension of the levees and closing the break the following force of men, horses and equipment: 1,220 head of stock, 375 Indians, 400 Mexicans, 500 white men, 4 steam shovels, 1 steamboat, suction dredges, 7 locomotives, not including those hauling rock on main line. In addition there are 200 steel side-dump cars of 45 cu. yd. capacity and 450 flat cars in this service exclusively, and the equipment trains and men working in the various outside quarries. Four top and two floating pile drivers had been in use until the completion of the trestle. The total volume of earth to be moved in the levees is 880,000 cu. yd. The total volume of rock which will probably be required to complete the dam proper is something in the vicinity of 100,000 cu. yd., and there will be some 75,000 cu. yd. of clay and gravel.

View Taken while Repairing Trestles.

The work of unloading rock was begun on Jan. 27 and on Feb. 10 the water was practically shut off at the recent break, although on account of percolation some of the material dropped down in a few places and let a little water get over the top. The total head, which was all developed on the lower trestle, was 12.45 ft. The lower trestle will be filled in with clay and gravel to make an impervious upstream gravel face. The quantity of water in the river on Feb. 10 was about 20,000 cu. ft. per second.

In the fourteen days' work on closing this last break there were put in place 2,202 carloads of material, aggregating about 52,000 cu. yd. of rock, 5,000 cu. yd. of clay and about 20,000 cu. yd. of gravel. The total length of the trestle is 1,125 ft. and the water was allowed to pour over 680 ft. of this. The maximum amount of water that ever went over the dam was about 35,000 second-feet. The overflow was not uniformly distributed over the entire length of the dam so that in places for several hours there was undoubtedly as much as 100 cu. ft. per second per linear foot going over the dam.

Mr. C. K. Clarke, until recently resident engineer of the Southern Pacific R. R. on the Tucson division, is in charge of the diversion work proper, and Mr. Thomas J. Hind, who was superintendent of the dam finished Nov. 4, is superintendent of the levee reconstruction and extension.

After this article was put in type Mr. Cory sent the following notes concerning the conditions up to February 19:

In the article I suggested three possible methods of failure, the last of which was a very great flood might come and overtop the entire dam before it could be raised above possible high water mark. We have been receiving from the beginning, morning, noon and night, reports as to the condition of the Gila, Salt and Colorado Rivers from San Carlos, Phoenix and Sacaton, Ariz., and Needles, Cal.

By securing reports in this way we have always been able to anticipate changes in the river, and when the closing was technically made it was seen that we had at least three days when no rise of the river was possible. Accordingly we filled in the trestle, took out the stringers and raised the track, using for the purpose gravel from the Mammoth gravel pit, about 40 miles west of Hanlon Junction, and clay from the clay pit on our own tracks.

We began dumping rock for the first time at 4 o'clock, Sunday, Jan. 27, and at 11 p. m., Sunday, Feb. 10, all of the water was shut off, and the close had been effected, technically speaking, although quite a considerable amount was percolating through the dam.

By Sunday, Feb. 17, as a result of this work, there was not over one cubic foot per second passing through its entire length.

We unloaded a little over 1,100 cars the first week, 2,202 cars the first two weeks, 3,318 cars in the three weeks, thus making a very close average to 1,100 cars per week. By far the greater proportion of this ranged between 45 to 50 yards each.

It is a rather interesting fact that during the first twelve hours of our dumping we unloaded 145 steel side dump cars of rock, averaging 45 yards each, or a total of 6,600 yards. We have never unloaded so much material thereafter in the same length of time, but within the three weeks we have put over 110,000 cu. yd. of material in place in the dam.

SEVERAL CORRECTIONS to the article on the Minidoka project elsewhere in this issue were received after the part of the paper containing it had been printed. On page 244, second column, line 19, strike out all of the paragraph after "solid rock" and substitute "and all structures are founded on bed rock." On page 245, second column, line 22, insert the name of Mr. L. L. Gay before that of Mr. Connor. On page 246, second column, line under illustration, substitute Mr. L. L. Gay for Mr. Smith.

Difficult Foundations of the Hoffman House Extension, New York.

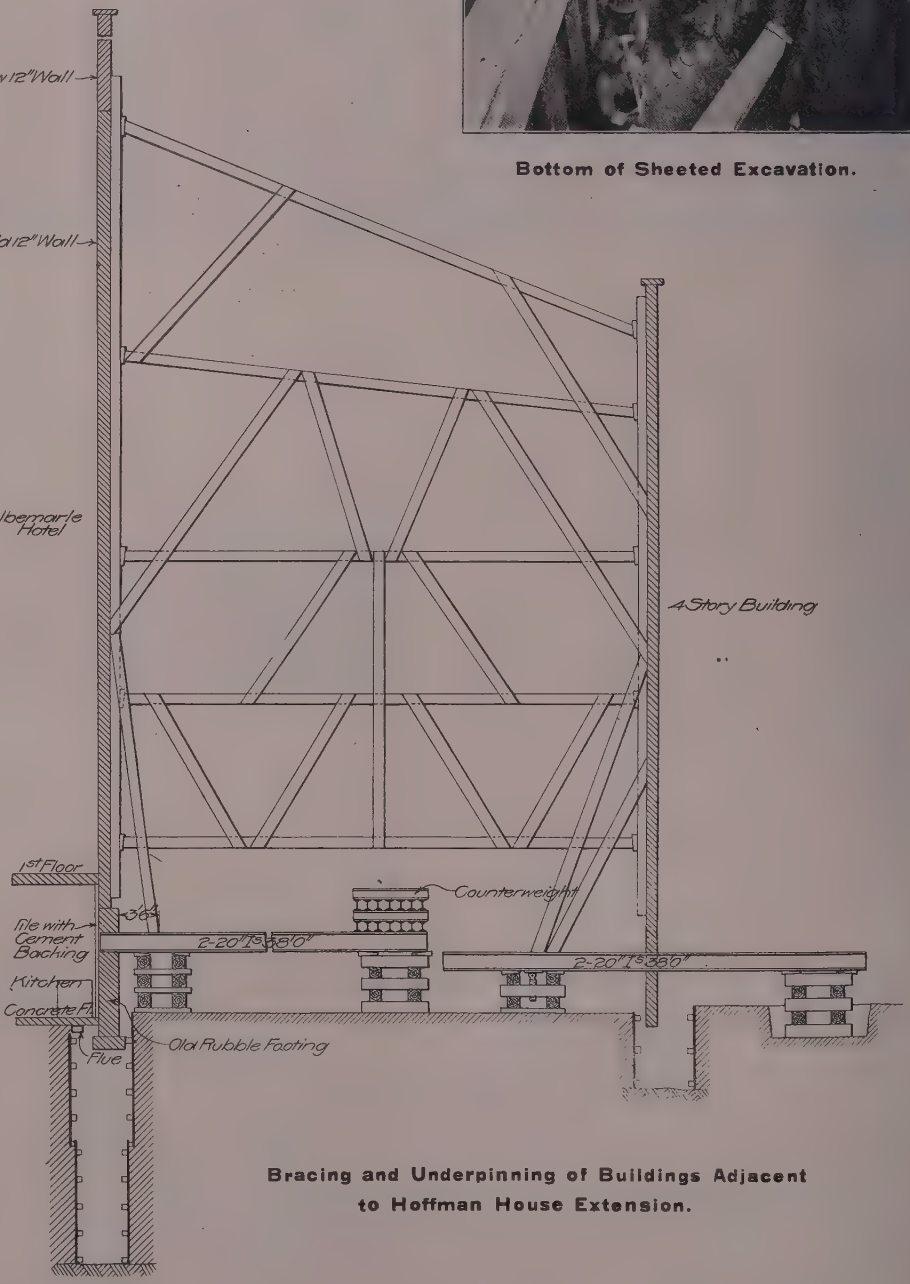
The L-shaped extension to the Hoffman House at 24th St. and Broadway, New York City, is a twelve-story fireproof steel-cage structure with a frontage of 48 ft. on 24th St. and 60 ft. on Broadway and a depth of about 100 ft. It occupies the site of a former four-story brick and stone wing of the hotel and is enclosed, except the street fronts, by the walls of the other portion of the hotel and by adjacent buildings.

On the 24th St. side, one of the adjacent structures is a four-story and basement residence with a brick party wall 12 in. thick and about 60 ft. long, which was supported on a brick footing seated on the mud about 8 ft. below the level of the street. It had served as a party wall supporting the floors on both sides and the top overhanging the Hoffman House lot was 11 in. out of plumb. The wall was laid up in lime-mortar and was found in a very weak and poor condition with many voids and loose bricks and with a large number of flues, chases and other recesses cut into both faces. These were carefully bricked up at the commencement of operations and cement grout was forced into all the accessible cavities in the brickwork, and between the face brick and the wall, thereby considerably solidifying and strengthening the wall. At the front there is an L-shaped corner pier forming the angle between the front and side masonry. This pier was about 3 ft. wide on each of the outer faces and its thickness of 2 ft. was made up of a brick wall veneered with marble. It was thus a slender masonry column. At its rear corner there was a vertical row of windows adjoining it, immediately supported between cap and sill pieces by vertical shores in each of them, so that the brickwork between them was independent of the pier; the latter was then taken down and rebuilt with Portland cement.

On the opposite side of the 24th St. wing, the lot is bounded by the Albemarle, a seven-story and basement hotel with a 12-in. brick wall nearly 100 ft. in height. The thickness of the wall is uniform from a point just below the first floor to the top of the parapet above the penthouse roof, but it is composed of two portions, an old wall five stories high on which there is seated without bond or reinforcement the new upper portion of the wall. The old wall was carried by a rubble masonry foundation 22 in. thick and about 8 ft. high, poorly laid up in lime-mortar; it contained many cavities, loose stones and small stones, and was seated on the mud just below the basement floor about 10 ft. below the street level. This wall was also somewhat out of plumb, leaning over into the adjacent lot, and at the street end was disconnected from the front wall of the Albemarle by the removal of the brown stone front of the old adjacent building.

As the width of the lot was only 48 ft., it was practicable to brace the walls of the buildings on opposite sides with a system of horizontal overhead transverse struts across the lot, and this was done as indicated in the transverse section, with five tiers of 10x10-in. timbers about 9 ft. apart vertically and 15 ft. apart horizontally. All of them were approximately horizontal except the upper timbers, which were inclined from the top of the four-story wall to a higher point on the seventh story wall, so as to brace the joint in the brickwork there. The ends of all the struts had wedged bearings against vertical 10x10-in. distributing beams, which in turn were wedged at many points of their length against the irregular face of the brickwork so as to afford it approximately continuous support. The struts were stiffened and their span diminished by kneebraces and diagonals of 3x12-in. planks, thoroughly spiked to them and arranged as indicated to stiffen the long beams and diminish their deflections rather than to constitute any regular system of trussing, which was unnecessary as the members had no bending moment except that due to their own weight and acted merely as struts. The struts were arranged in vertical planes which are braced together by center lines of horizontal timbers parallel with the walls, not here shown.

Bottom of Sheeted Excavation.



Bracing and Underpinning of Buildings Adjacent to Hoffman House Extension.

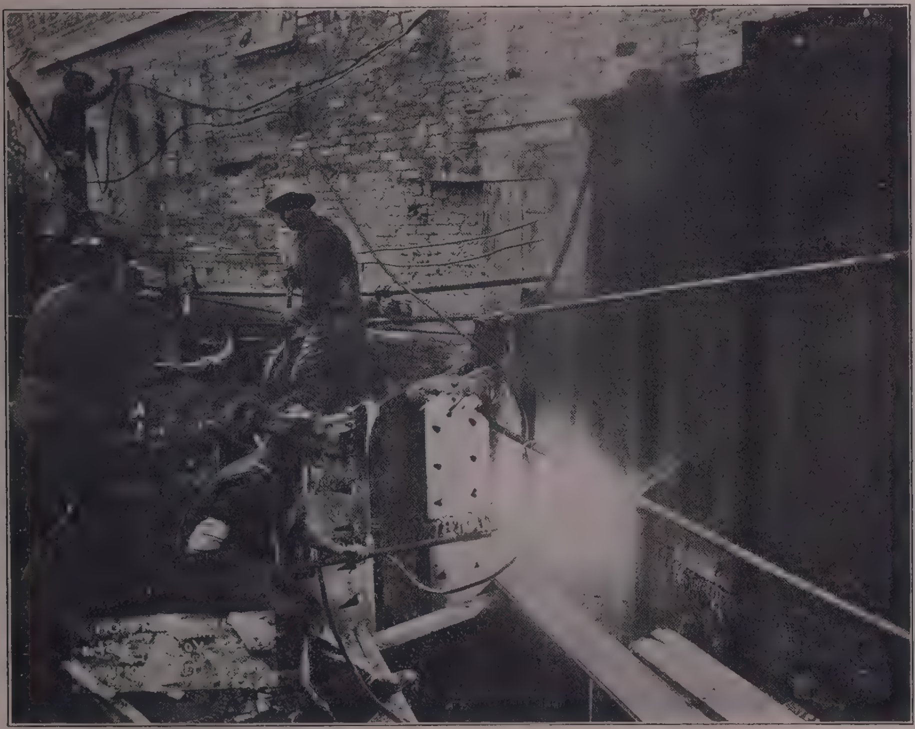
Before underpinning the house on the west side, a continuous grillage of 3x12-in. transverse planks 8 ft. long was laid on the leveled surface of the lot with the ends of the planks about 4 ft. clear of the foot of the four-story wall. On them was laid a pair of longitudinal 14x14-in. timbers 30 ft. long, breaking joints. On these short transverse beams were set about 5 ft. apart in the clear, each of them carrying the feet of two 10x10-in. spur braces wedged to efficient bearing against the seats cut for their upper ends in the brick wall. Midway between the pairs of spur braces there was placed a needle-beam, each of them consisting of two horizontal 20-in. I-beams 38 ft. long. The outer end of each pair of beams was supported on a 4-in. jackscrew seated on a horizontal transverse timber supported by the longitudinal sills. The upper end of the jack engaged a bearing plate across the lower flanges of the I-beams, and as the jack was operated, pairs of oak wedges were driven between the upper tier of longitudinal sills and the I-beam flanges on both sides of it, to take up all space as fast as gained. The I-beams projected through the wall into the cellar of the building, where their inner ends were seated about 15 ft. from the center of the wall on two 14x14-in. longitudinal sills with a double-plank grillage

8 ft. wide, set in a trench dug 3 ft. below the cellar floor. After the wall was thoroughly secured by the braces and needle-beams, the footing below the latter was removed and a trench 4 ft. wide was sheeted down on its center line to the hard rock at a depth of 20 ft. below the curb. This was filled with concrete to within a foot of the cellar floor level, above which a new brick footing was carried up to receive the old wall at the height of the needle-beams and was wedged against it in the usual manner.

On the opposite side of the lot the underpinning of the seven-story hotel wall was a more difficult matter on account of its greater weight, estimated at about 12,000 lb. per linear foot, and because the contractors were not permitted to enter the basement, thus necessitating the execution of all operations from the exterior. Three tiers of double 14x14-in. longitudinal timbers about 30 ft. long, breaking joints and separated by transverse 3x12-in. planks, were set parallel with the wall and about 3½ ft. distant from it on centers on a grillage made with a double layer of 3x12-in. transverse plank 12 ft. long. The upper sills support beveled transverse timbers 5 ft. apart in the clear with single 12x12-in. spur braces about 30 ft. long wedged to bearing in recesses cut in the brickwork.

Intermediate between the spurs were set cantilever needle-beams, each consisting of a pair of 20-in. I-beams, 38 ft. long, fulcrumed on the longitudinal sills. The ends projected into holes carefully cut through the rubble footing of the wall and new brickwork carried up to the old 12-in. wall. The beams did not extend beyond the masonry, which was fortunately covered on the inside with glazed tile laid in a cement backing which proved to be sufficiently strong to maintain the inner surface without the support of the old wall.

The opposite ends of the needle-beams were supported on timber cribbing wedged up to prevent any vertical motion, and were loaded with about ten tons each of steel beams, girders, columns or other heavy members belonging to the framework of the new building. The wedges under the anchorage were carefully slacked until the weight of the wall was fully taken by the cantilevers. The masonry footing below the needle-beams was then removed and a trench about 6½ ft. wide was sheeted down to rock on the center line of the wall in alternate sections about 6 ft. long and 6 ft. apart in the clear. The excavation undermined the outer edge of the 8-in. concrete slab forming the basement floor, and this was supported in the center of each section by a 6x6-in. cantilever or springing needle on the outside of the wall, not shown in the cross-section. The trench was carried down with two lengths of wood sheet piling to rock at a depth of about 33 ft. below the curb. It was filled solid with concrete up to the cellar floor, above which brickwork was built to the bottom of the old wall. A footing about 6 ft. long was thus made for the old wall without disturbing the tile facing or in any way interfering with the tenants in the building. While this work was in progress, accurate levels were taken night and morning by the engineers but no displacement or settlement of either building could be detected.



Cutting off Steel Sheet Piles by Electricity.

Before commencing operations, the site was explored by about 40 drill test holes by P. E. Nostrand, and an equal number of wash test holes made by the Phillips & Worthington Co., which indicated that the soil consisted of earth, sand, clay and loam overlying a thick bed of large and small boulders with occasional layers of quicksand reaching to the surface of the rock from 14 to 40 ft. below the curb. When excavation was commenced, these indications were verified and the work proved to be of extremely difficult character on account of the combination of boulders and quicksand, the large amount of ground water encountered 10 ft. below the curb and the danger of undermining the adjacent buildings, none of which had footings carried to the rock.

On the 24th St. front, the entire excavation was carried down into the solid rock in open trench, the pit being drained to a sump. The old cellar floor was about 9 ft. below the curb and the new one for this part of the building is about 38 ft. lower, necessitating a large amount of rock excavation, which is done in the ordinary manner with five Ingersoll-Sergeant steam drills, the holes being fired with light charges of 40 per cent. forcite and the rock covered with timbers chained together and rope mats to prevent danger from flying stones. On the Broadway wing, the general excavation is only about 11 ft. deep and does not reach to rock, but the column piers are carried down to a depth of 38 ft. and considerable difficulty was experienced in holding up the sides adjacent to the streets where they were protected by interlocking steel sheet piling braced with horizontal wooden wales stiffened by knee-braces and by rakers.

Earth, loose rock and boulders were excavated by hand and shoveled into 1½-yd. steel buckets delivered by 20-in. industrial tracks furnished by Arthur Koppel, and run on the bottom of the excavation to the 24th St. front. The trussed struts between the old buildings on opposite sides of the lot obstructed the lot so much that a derrick boom could not swing freely enough to reach the excavation and deliver to the wagons in the street, therefore it was necessary to set the derrick with the mast on one side of a set of struts and the boom on the opposite side with just swing enough to lift the bucket from the track and deliver it to the wagon, thus handling the material under considerable difficulty.

The thirty steel columns in the Broadway wing are seated on separate concrete piers carried down to rock from 10 to 28 ft. beyond the cellar floor which is 11 ft. below the curb. Very great difficulty was experienced in sheeting the 6x6-ft. open pits for these piers. Cofferdams were made with Friestedt interlocking steel piles composed of 15-in. 33-lb. channels driven by 2,000-lb. pile-driver hammers. The average length of the piles was about 20 ft. each, but as the surface of the rock was extremely irregular, it was necessary to order the piles much longer on account of the uncertain bottom. In some cases, the surface of the rock varied abruptly; in one instance, a line of piles followed a fault in the rock which produced a vertical drop of 6 ft., and one set of the piles engaged the top of this little cliff while the other set interlocking with it, cleared it and descended to the lower level.

The greatest difficulty was due to the numerous very large and very hard boulders, many of which could neither be deflected nor broken by the piles. When these were encountered near the surface of the ground, they could sometimes be removed by digging an open pit to them. In ordinary cases, they were inaccessible and the line of sheeting had to make a detour around them, bringing them inside the pit. When the piles encountered boulders too large to be deflected, they crippled badly and in many instances were found afterwards to be torn to pieces. Notwithstanding these difficulties, all of the piles were by some means driven to the rock or the spaces between them were closed by sheeting and calked as the excavation was made. All faces of the 24th St. excavation, except wherever new underpinning footings were provided for the adjacent buildings, were also protected by about 200 lin. ft. of steel sheet piling like that used for the piers. The piles were driven by a special hammer arranged to slide in front of the guides of an ordinary pile driver tower and thus work close to the face of the wall. The piles were driven without caps or followers, and as no limit was placed on the drop of the hammer the upper ends of the piles were badly battered, a circumstance which was not so objectionable since they were all permanently left in the ground and all of them were necessarily longer than was requisite, so that the upper ends had to be cut off in any event and were only valuable for scrap. The joints between the piles were found to be generally tight and satisfactory, except where the piles had been badly damaged by driving and some of the flanges were broken off. The water, however, was kept down by means of one or two pumps in each pit and enabled the materials to be excavated down to the rock and oakum packed in the open spaces in the irregular joints between the bottoms of the piles and the rock and at such places as the piles were stopped by large boulders. Although the piles developed a considerable degree of stiffness, it was necessary to brace them with one or two tiers of 10x10-in. pieces wedged against the face of the piles. Ordinarily these were stiff enough to support the sheeting without intermediate cross struts, thus leaving the pits practically unobstructed for the concrete. The latter was hand mixed 1 : 3 : 5 with Atlas Portland cement and filled in up to the grillage. The piles remained permanently in position below the cellar floor.

A few inches below subgrade, the tops of the piles were cut off by hand. At first this was accomplished with electric drills and cold chisels. The cross-sectional area cut through was about 4 in. in extreme width, and although the single thickness of metal did not exceed ½ in., except in the flanges of the channels, the riveted locking bars increased the sectional area to an equivalent of about 14 sq. in. per linear foot of sheeting, which was cut through by two men at the rate of 1 ft. per day. The labor cost $9 and the electricity cost about $13, making so large a total that in the interests of economy and expedition, a device was installed for burning through the piles with an electric current. A connection was made with the 2,500-volt single-phase lines of the United Electric Light & Power Co., and the current was transmitted through four 20-kw. transformers wound for 50 volts and connected in multiple. One wire was bolted to one of the sheet piles and the other was connected to a carbon electrode mounted on a long wooden handle. The electrode was made of a 1¼x¾-in. carbon brush 12 in. long bolted between two 5x5x½-in. copper plates which required to be replaced every two days. The wooden handle of the electrode was mounted with a sliding suspension from a horizontal guide bar, and was operated by a man protected by an asbestos mask and gloves and large double black goggles which were found necessary to shield him from the vivid light and great heat, which otherwise blistered the skin and caused great pain in the eyes at a distance of 11 ft. The operation was very simple and consisted merely of making a contact between the electrode and the steel pile, care being taken to avoid displacing the electrode far enough to disrupt the arc. The arc consumed about 650 amperes at a potential of 50 volts and with it two men were able to cut through as much as 30 lin. ft. of sheet piles in eight hours at a cost of about $30 for both labor and electric current. The details of this electric apparatus were described in The Engineering Record of Dec. 8, 1906, where the figures given for the cost and maximum speed of operation varied from the above because at that time data were not available for the maximum efficiency here described.

Operations were commenced July 1, 1906, in removing the old structures from the site; underpinning was commenced Sept. 25, and completed January 1. General excavation was commenced Dec. 15 and the earth excavation has now been completed, but the rock excavation is still in progress. In the Broadway wing all of the piers have been completed, the grillages set on them and part of the first tier of the columns were erected on Feb. 15.

All of the steel is unloaded from wagons in the street, handled and erected by two boom derricks with 60-ft. booms of 10 tons and 20 tons capacity operated by Lidgerwood electric engines. The site is so small and so much obstructed by the bracing and spur shores that very little steel can be stored there, and it is therefore delivered as nearly as possible, only when required for erection. The average force comprised a total of about 80 men including thirteen shorers, five drill runners and forty laborers, besides steel men, carpenters and others. The principal quantities include about 4,000 yd. of rock excavation, and 8,000 yd. of earth excavation. About 450 tons of steel, comprising the first tier in the Broadway wing, had been erected Feb. 15, by an average force of 20 men. The steel piling was driven by two pile drivers equipped with Lidgerwood electric engines, and the water was pumped from the pier pits and sumps by several hand pumps and miscellaneous steam pumps and by a Dayton hydraulic-electric pump.

Mr. R. L. Daus, is the architect of the building, and the general contract for its construction was awarded to the Thompson-Starrett Co., Mr. George Simpson, chief engineer, and Mr. C. S. Neal, superintendent in charge. The structural steel work was fabricated by the Empire Bridge Co., and is being erected by the general contractors.

Waterproofing a Reservoir.

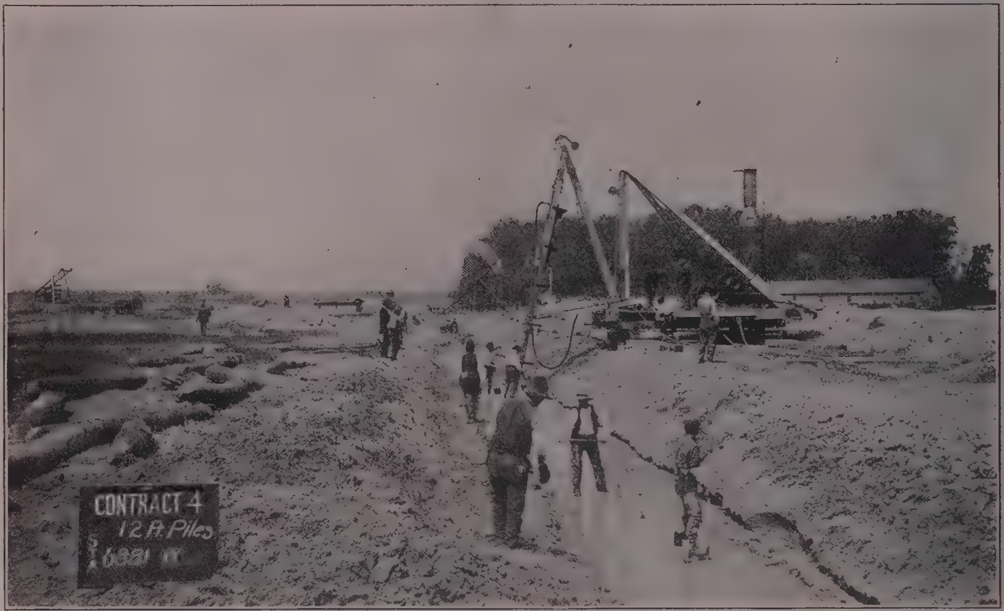
A method of waterproofing concrete has been tried on the new 500,000-gal. reservoir of the water-works of Uxbridge, Mass., with the result that the daily leakage has been reduced from 30,000 to 5,000 gal. A 1-in. layer of pitch and tar was spread over the reservoir bottom and was then covered with a 2-in. layer of 1 : 2 cement mortar. This was allowed to extend up the sides, thus covering any cracks at the joining of the side walls and bottom. A test made after this treatment had been applied showed a daily leakage 8,000 gal. less than that indicated by the first test. A wall of brick 2 ft. high was then built around the inside of the reservoir, a 1-in. space being left between the brick and the side wall. This space was filled with a special composition of tar and pitch. The wall was continued up to a height of 18 ft., the composition being poured in hot and the whole space filled. The face of the brick wall was then given two coats of neat cement. The cost of the work was $700.

The Construction of a Large Blast Furnace has been accomplished in five months at the South Buffalo yards of the Lackawanna Steel Co. It is 91½ ft. high and 22 ft. in diameter at the bosh. In addition to the furnace the work involved the building of a boiler house, the installation of ten 400-h.p. Stirling boilers and the laying of 2,200 ft. of new water mains. No serious delays were experienced in machinery deliveries and much of the metal work was done in the company's shops.

Steam Pile and Sheet-Pile Drivers on the New York Barge Canal.

By Emile Low, M. Am. Soc. C.E.

In The Engineering Record of April 21, 1906, there appeared an article describing a German excavator employed by the Empire Engineering Corporation, in excavating pile trenches and ditches on Contract No. 4 of the New York State Barge Canal, which work is now in charge of Mr. Frederick Skene, State Engineer and Surveyor, and Mr. William R. Hill, M. Am. Soc. C. E., Special Deputy State Engineer. As stated in the article in question, the plans for protecting the slopes of the canal prism called for a wash wall of broken stone extending above water level. The toe of this wash wall was to be supported by a so-called bank protection foundation, consisting of a row of piles 12 ft. long, driven 8 ft. apart, in a line parallel to the axis of the canal, capped by a 6 x 8-in. waling, behind which a course of tongued sheet piling 8 ft. long and composed of three 1-in. boards was driven.



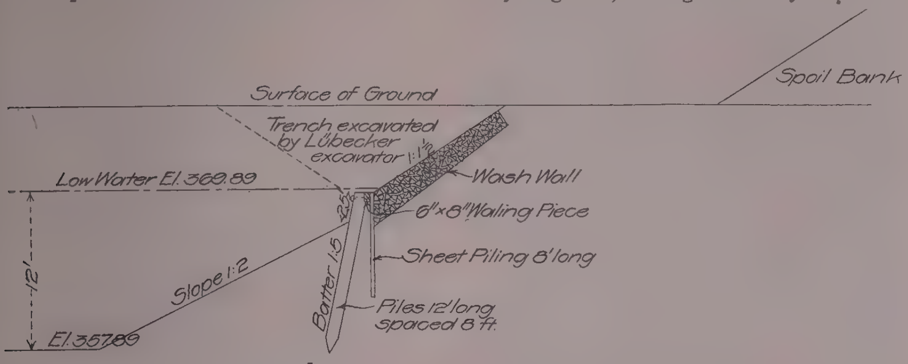
Driving Piles for the Foundation of the Bank Protection.

As the tops of the piles, waling and sheet piling were 3 in. below low water (El. 369.89) it was not considered advisable to drive the bank protection from floating pile-drivers. Instead it was concluded to drive the same in the dry. To do this a trench, triangular shaped in cross-section, was excavated by the Lübecker excavator along the two inner slopes of the canal prism, the bottom of the trench corresponding with the top of the piles. The material from the trench was placed in the adjacent spoil bank, forming dikes or levees, behind which later on the material was pumped by a hydraulic dredge from the canal prism.

A number of forms of pile-drivers with which to drive the piles and sheet piling were considered, but it was finally concluded to use one form for driving the piles, and another form for driving the sheet piling. The pile-drivers consisted essentially of a large platform built of heavy timbers and floored over with heavy plank. Upon this platform was erected a substantial stiff-leg derrick with boom. A hoisting engine with boiler was also placed on the platform.

The pile-drivers were run along the space between the top of the slope and the foot of the spoil bank, this space being 16 ft. wide. A temporary track was laid on this space, the 6 x 8-in. wales being used for this purpose.

The drivers were propelled along by means of pipe rollers. It will be noted that the roller spools resting upon the pipes were used for moving the driver laterally. "Dead men" were placed ahead of the drivers, to which a line with pulley block was attached. By winching the free end around the drum of the hoisting engine the driver was pulled forward.



Bank Protection Used on Contract 41.

For driving the 12-ft. piles, Warrington patent improved steam pile hammers, made by the Vulcan Iron Works, Chicago, were used. The leads were hung from the derrick boom, as shown in the picture. The piles were driven on a slope or inclination of 1 on 5, the leads being set to accomplish this.

As the material into which the piles were driven was a very fine, gray sand, mixed with a little clay, a water jet had to be used in driving. After the piles had been driven, the tops were sawed off to the required grade and also notched to receive the waling. All holes for bolts were bored by hand. The almost fluid condition of the sand, when mixed with water, gave no small amount of trouble, and much difficulty was experienced in keeping it below the top of the work.

For driving the sheet piling, a similar driver to the pile-driver was used, the exception being that for driving a modified Ingersoll-Rand rock drill was used, being suspended from the boom by a wire cable.

Trench in which Sheet-Piling of Bank Foundation is Driven.

Lübecker Excavator for Pile Trench for Bank protection.

This pile-driver is an adaptation of the Ingersoll G drill to this special line of work. The cylinder is 4 in. in diameter and the stroke from 7 to 8 in., the piston making a full stroke for each blow and striking an anvil in a foot piece fitting on top of the sheet piling. When the piston strikes the anvil, which has a limited movement in the middle of the foot piece, there is little clearance left between the piston and the front or lower head, and by means of a little regulating screw at the top of the chest the stroke may be so adjusted that the piston on the up stroke will just avoid the top head. The clearances at both ends are quite small, and there is little waste of air or steam in filling them, the economy in this respect being much greater than with the ordinary rock drill. As the piston moves independently of everything else, having no heavy chuck on its lower end and no weight of drill steel to lift, the lower or lifting piston area is made much smaller than normal by increasing the diameter of the rod. This saves air for each up stroke and also strengthens the piston so that breakages are unheard of.

The foot piece is connected to the cylinder by heavy rods, independent of the regular side rods which hold the heads as in the regular rock drill. The anvil in the center of the foot piece is slotted and is held in place by cross bolts which permit sufficient vertical movement independent of the foot pieces. As the piston descends and strikes the anvil its momentum is transferred to the latter and through that to the head of the piles upon which it rests. The blow is like the dead blow of a heavy sledge, and, unlike the hand sledge, the blows can be delivered with great rapidity so that an almost continuous movement may be imparted to the pile until it is driven home. The valve movement is entirely automatic and always ready, nothing being required but a sufficient pressure, the ordinary working rock drill pressure, and the manipulation of the throttle. There is nothing about the pile-driver to get out of adjustment, and sufficient and frequent lubrication is all the care required. There are no delicate or fragile exposed parts and the apparatus as a whole will stand any amount of neglect and more than a reasonable share of abuse. The pile-driver is suspended and handled by a derrick, the chain hanging loose while driving. The lifting and shifting to another plank is of course a simple operation, so that the driving can be carried on as rapidly as the planks can be set up.

The sheet piling was 8 ft. long, made up of boards 8, 10, or 12 in. wide, as the case might be, the boards being 1 in. thick. At first single sheet piles were driven, then later on three were put together, and this was changed to two driven as one. It was also necssary to use a water jet in driving the sheet piles.

The contract price for the 12-ft. piles is $2.85 each, driven, while the price for the waling and sheet piling in place is $26.40 per M. ft. B. M.

The necessary force to operate these machines was as follows: For the 12-ft. pile-drivers: 1 foreman, 1 engineman, 1 fireman, 2 laborers. For the 8-ft. sheet pile-drivers: 1 foreman, 1 hammerman, 1 winchman, 1 fireman, 2 laborers.

A much larger force than this was employed, which was required to keep the trench clear of the inflowing sand.

At times considerable delays were experienced on account of sunken logs encountered along the line of the driven piles. These were found from 2 to 5 ft. below grade, and varied in diameter from 6 to 18 in. The time of the delays ranged from one hour to two days. Several methods were used in getting rid of these sunken logs. Those near the surface were usually sawed out or cut in two by means of a large wood chisel. Those deeper down had to be laid bare by excavation and then sawed or chopped out. Some dynamite was used, but it damaged the completed work to such an extent that its use was abandoned.

It is a little difficult to give an exact account of the work done by these drivers, of which there were two of each kind, pile and sheet pile-drivers. This for the reason that all were not always at work, and again they worked at times single shifts and at other times double shifts.

During the month of August, 1906, the number of 12-ft. piles driven was 435, or a daily average for 27 days of 16 piles. The force account for this work was as follows:

10	days	foremen	$100.00	per mo.	$37.03
47	“	foremen	3.00	“ day	141.00
13¼	“	machinists	2.80	“ “	37.10
72¼	“	enginemen	2.00	“ “	144.50
332¼	“	laborers	1.60	“ “	531.60
17	“	laborers	1.50	“ “	25.50
17½	“	laborers	1.40	“ “	24.50
26	“	watchmen	1.60	“ “	41.60
1	“	waterboy	.75	“ “	.75
68⅞	“	team	3.50	“ “	241.06
					$1224.64

It must be remembered that a large percentage of the labor was in keeping the trench clear of the fine sand which continually flowed in, covering the tops of the piles, and had to be removed before the tops of the piles could be sawed off and fitted for the reception of the wales. Later on this fine sand covered the finished waling and had again to be removed before the sheet piling could be driven. It may be stated here that an auxiliary wale was temporarily placed 3 in. from the permanent one, as an aid in driving the sheet piles, which were driven in the groove so formed. During the same month 12,272 ft. B. M. of waling was placed. The cost of the same was as follows:

22¼	days	foremen	$100.00	per mo.	$82.40
4	“	foremen	2.50	“ day	10.00
32⅝	“	carpenter	2.50	“ “	81.56
57¼	“	carpenter	2.00	“ “	114.50
8¼	“	enginemen	2.00	“ “	16.50
134⅛	“	laborers	1.60	“ “	214.60
9	“	laborers	1.40	“ “	12.60
18	“	waterboy	.75	“ “	13.50
1⅛	“	team	3.50	“ “	3.93
					$549.59

During the same month 3,279 sheet piles were driven. There were 1,389 8-in., 1,108 10-in., and 782 12-in. piles, containing a total of 63,152 ft. B. M. lumber.

The force account for this work was as follows:

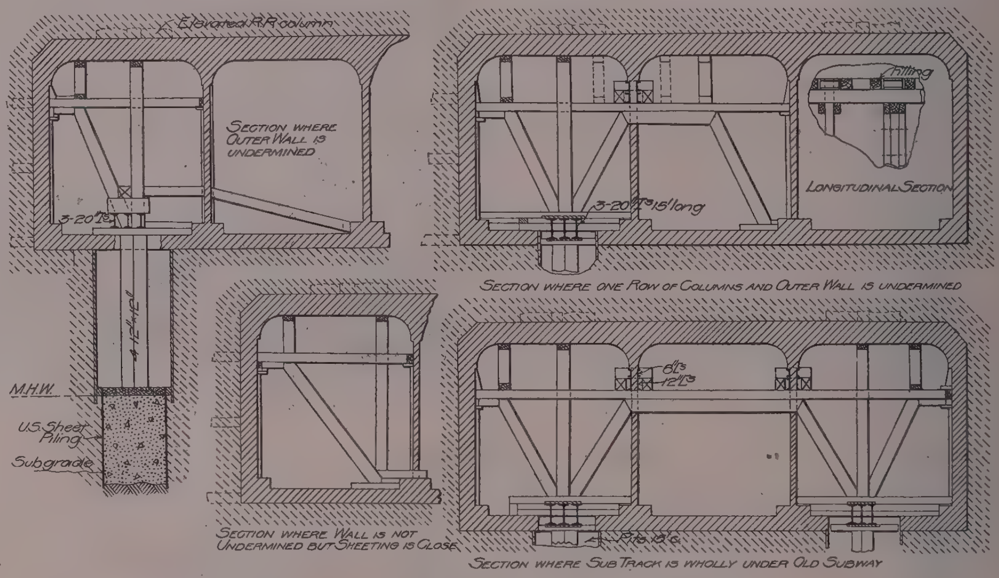
18	days	foremen	$100.00	per mo.	$66.66
68⅜	“	foremen	3.00	“ day	195.12
14⅜	“	machinists	2.80	“ “	40.25
103	“	enginemen	2.00	“ “	206.00
65½	“	carpenter	2.00	“ “	131.00
44⅝	“	carpenter	1.60	“ “	71.40
3	“	laborers	2.00	“ “	6.00
406¼	“	laborers	1.60	“ “	650.00
41⅝	“	laborers	1.50	“ “	62.43
4	“	laborers	1.40	“ “	5.60
26	“	watchmen	1.60	“ “	41.60
64⅞	“	teams	3.50	“ “	227.06
					$1703.12

A New Style Rubbish Can, adopted a year ago by the street cleaning department of Denver, Colo., is said to be more sanitary than the usual garbage and rubbish receptacles. It is a patented device, 36 in. high and 19 in. square, and rests on adjustable feet, which can be raised or lowered to fit the inequalities of the sidewalk or the slant of the particular post to which the can is attached. The can has no bottom, but a large sack is provided, the mouth of which is attached to four hooks in the top corners of the casing, and the bottom of which hangs clear of the sidewalk. The can has a removable hopper top and when this is locked in place the sack cannot be removed by any one but the authorized employes of the city. The bottom of the sack is perforated to allow the ready escape of moisture, and it is provided at the top with a draw-string for closing it. When the full bag is removed from the can, it is at once replaced with an empty one. This apparatus is said to be giving satisfaction to the authorities.

Underpinning a Three-Track Subway.

The original structure for the New York Rapid Transit Railway at Flatbush Ave., Brooklyn, is of the standard rectangular cross section of concrete steel construction with two lines of intermediate steel columns, the roof being strengthened by steel beams where it supports the elevated railroad columns. The structure is about 40 ft. wide and 16 ft. deep over all, and is designed to support the street, two surface car tracks and columns of the elevated railroad on its roof. The weight of the steel and the concrete structure itself is estimated at 25,000 lb. per lin. ft. and an allowance of three or four times as much more must be made for possible loading from the earth fill, street, surface car and elevated structure and trains.

After the completion of a portion of this subway, it was decided to add other tracks on both sides at the same or varying levels and to provide for an additional track crossing underneath it, thus involving undermining it partially for about 750 ft. and undermining it across the full width for 250 ft. The bottom of the invert for the upper tracks is about 23 ft. below the curb and is seated on fine dry sand about 10 ft. above ground water level. The footings for the new construction are carried down to a depth of 35 to 40 ft. below the curb or about 5 ft. below the original ground water level.


Elevated R.R. column
Section where Outer Wall is undermined
3-20" I's
4-12"x12"
M.H.W.
U.S. Sheet Piling
Subgrade
3-20" I's 15' long
Piling
Longitudinal Section
Section where one Row of Columns and Outer Wall is undermined
8" I's
12" I's
Section where Wall is not Undermined but Sheeting is Close
Pile 18' c
Section where Sub Track is wholly under Old Subway

Shoring for Undermined Portions of the Subway.

The excavation was first made alongside the existing structure down to ground water level, and sumps were sunk which gradually lowered the height of the water about 4 ft. so as to permit the completion of the excavation in the dry. Where the existing subway was to be undermined across its full width, rectangular holes 6 ft. square 25 ft. apart transversely and 15 ft. apart longitudinally were cut through the subway floor near the center lines of the two outside tracks. From them 6x6-ft. excavations were carried down to ground water level and were sheeted by 6x2-in. horizontal planks with their ends halved and notched together so that the four pieces in each course made a complete rectangle self braced sufficiently to withstand the moderate exterior pressure from the loose sand which held them in position as they were placed successively from the top downwards. The corners were provided, when the excavation was completed, with vertical cleats braced by occasional rangers.

When the excavation reached the ground water line, this method of sinking was abandoned and an inside 5x5-ft. cofferdam was built with 6-ft. sections of United States sheet piling driven with wooden followers by a small hand hammer machine made by the Pierce Well Engineering and Supply Co., operated in the subway or in some cases at the street level. After the completion of the steel cofferdam, the sand in it was excavated to 4 ft. below the reduced water level and it was filled with concrete carefully deposited under water, forming a portion of the permanent floor of the sub-subway.

In some cases when the pits were not directly adjacent to the excavation, the sheet piling was omitted and groups of 4-in. pipes 6 ft. long were driven in the bottom of the pit and filled with concrete making piles to carry the footing to the required depth. The tops of the piles were enclosed in a 12-in. layer of concrete with the upper surface at subgrade. When the concrete in the cofferdams and above the piles was hard, timber sills were placed on it and received the feet of groups of four 12x12-in. vertical timbers bolted together. The upper ends of these timbers projected just above the subway floor and were capped with sets of three 20-in. longitudinal I-beams 18 ft. long. On these beams transverse timber bents 5 ft. apart were set and braced to form supports for the roof columns and side walls of the subway. The ends of the 20-in. beams abutted, making practically continuous supports for the bents and carrying the full weight of the subway for short sections until it was completely underpinned and reinforced from below.

Here the intermediate subway columns were engaged by pairs of horizontal 12-in. channels breaking joints and bolted to them back to back across opposite faces to form a continuous longitudinal girder with the bottom flanges bearing on the transverse beams and the upper flanges receiving roof loads from short distributing channels, cross caps and blocking shown in the general cross section. The loads from these channels were transmitted directly to three-segment wooden arches sprung between the main longitudinal girders and counterbraced by inclined posts bearing against the side walls of the tunnel where longitudinal strips were fitted to take the weight of the roof on the ends of the transverse beams.

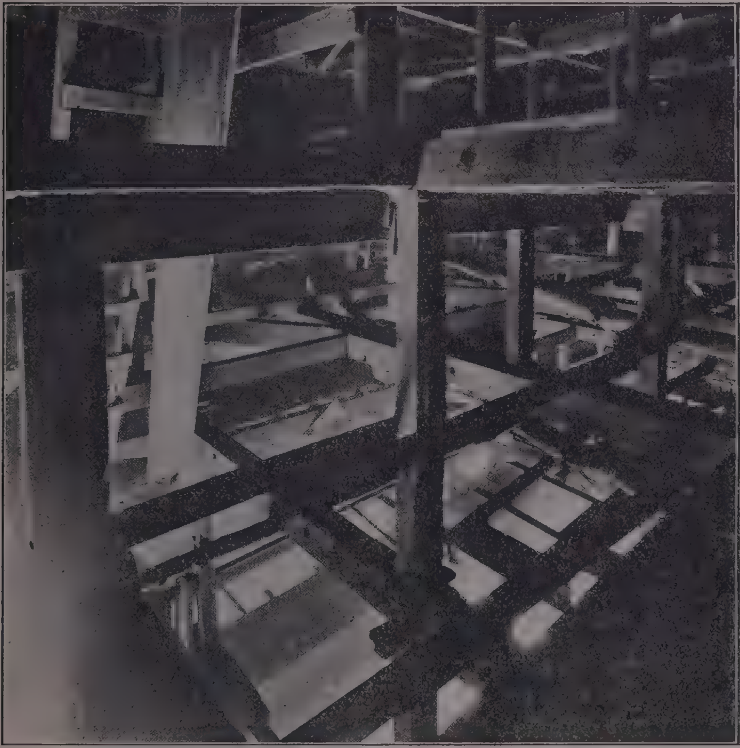
Where the full width of the tunnel was not undermined, one row of main vertical supports was omitted and the bracing was omitted in the undisturbed track. Where only one wall or part of one track of the subway was undermined, the structure was carried directly by single lines of vertical posts and rakers from sheeted pits and by longitudinal I-beams and shores with concrete pile temporary foundations, the wall being directly supported by ordinary vertical shoring placed as the excavation was made.

It was believed that the invert or floor of the subway would probably be strong enough to support itself from the roof and wall bracing, but no risk was taken and as fast as the earth was excavated under it, it was supported by blocking replaced by vertical shores of increased length as the excavation deepened.

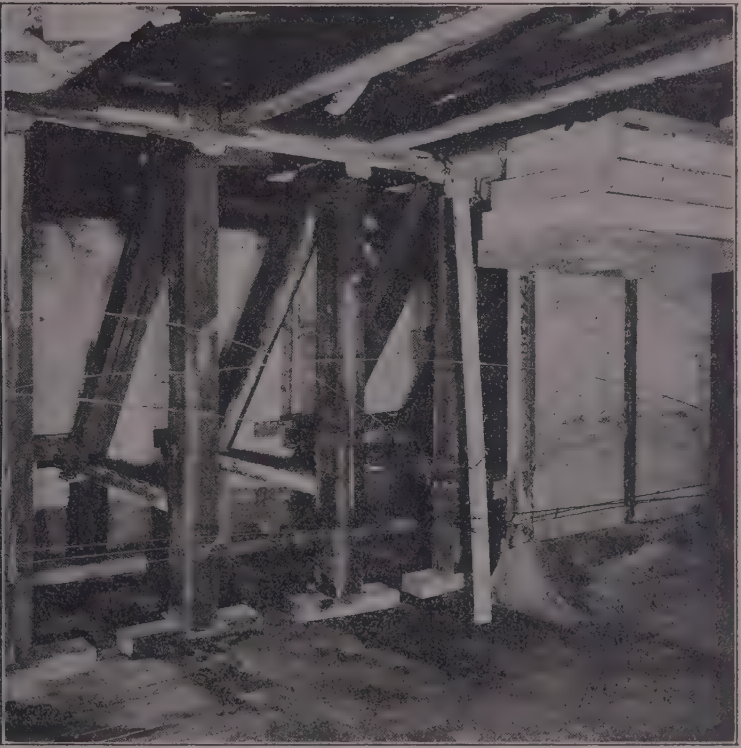
Excavation under and around the subway eventually made a trench with a maximum width of 80 to 100 ft. and a depth of about 40 ft., which was very heavily braced with transverse timbers at alternating distances of about 4 and 6 ft. apart on centers. These were supported by intermediate vertical columns and care was taken to arrange the latter so that they could receive loads from the subway and although not directly required for its support would provide very efficient auxiliary shoring for it in case of any settlement or displacement of the main timbering already described. They were therefore wedged up to careful bearing and arranged so as to distribute the pressure over greater transverse widths as the depths increased.

Footings were provided under the lower struts or sills by sinking two or three feet below water level, rectangular wooden caissons or headless oil barrels, both of which were filled with concrete and provided excellent foundations, multiplying the supports available for the subway. This evidently made abundant provision for carrying extremely heavy loads but is deemed no more than prudent on account of the unusual weight of the four-story structure. Its wisdom is demonstrated by observations when long and heavy elevated trains are passing at high speed, and even more when the electric street cars pass rapidly over the very rough surface tracks. The stresses combined with the heavy dead loads become very severe but do not cause any perceptible vibration in the structure.

Driving Steel Piles in Excavation.



Shoring and Bracing for Subway Roof



View of Heavy Trench Bracing.

Care is taken to arrange all of the timbering so as to permit the construction of the new subway in complete transverse sections 5 ft. long which alternate with open spaces 5 ft. wide. After the new concrete is old enough, the original subway together with the street, surface tracks and the elevated structure will be suported on it allowing the timbering to be removed and the intermediate sections of the new subway to be built. Some idea of the tremendous load carried may be formed by a consideration of the footing for one of the reinforced concrete walls which is made with a continuous grillage of 12-in. transverse I-beams 12 ft. long sufficing under ordinary foundation pressures for a load of 100,000 lb. per linear foot, an amount which may not be so excessive when it is remembered that the wall carries one end of a 38-ft. roof span of the three-track structure and directly supports the elevated railroad columns. Besides the work above mentioned, the construction involves the building of the subway stations and in some places provides for a six-track line, making very wide excavations and extremely heavy timbering which is being carried on while traffic is maintained uninterruptedly on the sidewalk, surface cars and elevated railroad. Spoil is handled in one-yard dump cars run on 20-in. industrial tracks to openings in the roof where it is hoisted to wagons in the street.

The work was designed and is being executed under the direction of the Board of Rapid Transit Railroad Commissioners, Mr. George S. Rice, chief engineer; Mr. F. C. Noble, division engineer. The Rapid Transit Subway Construction Co. are contractors, Mr. George H. Pegroun, chief engineer. The work is being executed by Cranford & McNamee under the personal direction of Mr. F. L. Cranford and Mr. J. C. Meem, their chief engineer.

Building Adobe Roads.

One very difficult problem in Californian road construction is the proper handling of adobe soil for roadbeds. A considerable mileage of country roads traverses this soil and is practically impassable during the winter months. Commissioner N. Ellery, of the State Highway Department, reports that a good and simple remedy is to saturate the adobe, when it is slightly plastic, with sand or fine gravel, so that it may have body and capacity to hold weight. Another matter that Mr. Ellery considers of importance in this connection is the necessity of exercising extra care in graveling or macadamizing work on adobe soil. If only a narrow strip of gravel or macadam is laid down, vehicles will pick up the wet adobe on either side, and, beginning at the shoulders of the road, will gradually force the gravel or stone into the mud, thus creating a rough road of adobe slush and uneven rock. In any road the resistance of even the best rock is severely taxed where the wheels are compelled by the narrowness of the roadway to follow practically one line. This condition, coupled with that just mentioned, leads Mr. Ellery to recommend a width of 16 ft. for the gravel or macadam improvement on adobe soils.

THE PREPARATION OF FILTER SAND for water purification works is a somewhat complicated process where the crude material contains clay and soil. The supply for the Washington filters, for instance, was first run through a grating to take out the largest lumps of clay, and then passed through a cylindrical screen, having round holes about ⅛ in. in diameter and water jets to assist the separation of the materials. The sand passing through these holes still contained considerable clay, so it was run through pug mills to pulverize the clay. Finally it was washed in boxes substantially like those described in this journal on July 2, 1904.

THE CONSTRUCTION OF THE TRINITY AND UNITED STATES REALTY BUILDINGS, NEW YORK.

The original Trinity Building in New York was a five-story brown stone front office building with a 41-ft. front on Broadway adjacent to Trinity churchyard near the head of Wall St. It was replaced by a modern steel-cage twenty-one story building erected in 1904, as described in The Engineering Record of May 20 and Sept. 3, 1904. After the erection of this structure, all of the adjacent property in the remainder of the block included between Broadway, Trinity Place and Cedar St., was acquired, and, with the original Trinity Building, covers an area of about 200x264 ft. This plot was originally intersected by Thames St., about 27 ft. wide and parallel with Cedar St., adjacent to the wall of the Trinity Building, and by Temple St., a narrow lane at right angles to Thames St. and connecting it with Cedar St. midway between Broadway and Trinity Place.

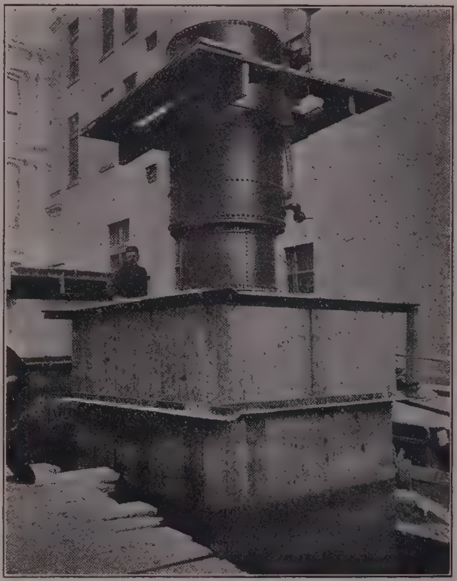
An arrangement was made with the city authorities by which Temple St., never much used by the public, was abandoned and an area somewhat greater than it had occupied was added to Thames St., increasing its width to 30 ft. Thames St. was at the same time moved parallel with itself to a new position 102½ ft. in the clear from Cedar St., thus leaving a strip 27½ ft. wide and 274 ft. deep adjacent to the Trinity Building, on which it was planned to erect an extension of the Trinity Building, giving the enlarged building a front of about 69 ft. on Broadway. The remainder of the lot on the corner of Cedar St. was formerly occupied by the Boreel Building. It now has a Broadway front of 102½ ft. and a depth of 64 ft. and is occupied by the United States Realty Building.

The extension of the Trinity Building is made to conform architecturally with the old structure so as to be integral with it and constitute a single building of gothic design, harmonizing with the beautiful church adjacent to it. The Realty Building, although structurally independent of the Trinity Building, is of the same type and general appearance, so that from the street both buildings appear to form a part of the same structure separated by an opening no more conspicuous than is often made by a deep light court. The two buildings, although designed by the same architect and built by the same contractor, are separate properties under different ownership, but since their construction was simultaneous, and the same plant was used for the extension of the Trinity Building and the construction of the Realty Building, no discrimination is made between them in this article and all statements made are considered as applicable to both unless special explanation to the contrary is made.

After the old buildings were razed, the entire area of the 160x74-ft. site, including Thames St. and Temple St. was excavated to a depth of 21 to 23 ft. below the curb by pick and shovel, and the 35,000 yd. of earth, sand and old masonry were removed by a force of about 300 men working day and night in successive eight-hour shifts. Spoil was shoveled directly into wagons, drawn out of the excavation on a wooden inclined plane. As fast as the excavation permitted, a wagon platform was built on framed falsework bents set up on the bottom of the excavation. It was T-shaped in plan and extended across the full length of the lot between the wall columns in the Trinity and Realty Buildings, completely covering Thames St. A similar platform at right angles to it extended from near the center point to Cedar St. Both platforms were 28 ft. wide and were graded to correspond with the streets, thus affording passage for trucks and wagons to deliver and remove materials.

Two stiff-leg derricks were installed between the platform and the old Trinity Building and two more on the site of the Realty Building. Two lines of framed trestles 22 ft. wide and about 90 ft. long were built parallel to the main wagon platform, between it and Cedar St., and on each of them was erected a traveling derrick tower equipped with four 40-ft. 8-ton booms. This arrangement provided 12 booms, which together commanded the entire area of the lot and sufficed for handling all materials and for the execution of the substructure work.

Elevated bridges were built over the sidewalk vaults on Broadway and Trinity Place and were covered by heavy wooden decks 15 ft. wide, designed for working and storage platforms and protected by a slightly inclined waterproofed ceiling underneath which served as a roof over the walk maintained for pedestrians in the street. A similar platform, 11 ft. wide, was built in Cedar St. for the full length of the building, from end to end of the lot, thus providing a total of about 8,000 sq. ft. of additional area for construction purposes. The excavation was protected on the street sides by United States steel sheet piles and by 4x12-in. yellow pine sheet piles driven by drop hammers and by a Vulcan steam hammer and braced by several tiers of wales with horizontal and inclined transverse struts.



Top of Pneumatic Caisson Pier Built above Surface.

Rectangular wooden, and circular steel, caissons and cofferdams for the concrete piers were delivered in sections by wagons, and were unloaded and set in position by the derrick booms, holes being cut through the wagon platforms to receive them when necessary. The concrete piers were built on top of the pneumatic caissons and their forms were removed before the latter were sunk, thus effecting a considerable saving in cofferdams and facilitating the sinking by utilizing the great weights of the piers themselves. The piers were sunk to solid rock or hardpan at an average depth of 75 ft. below the Broadway curb. They were fitted with collapsible steel shafts afterwards removed and the spaces filled with 1:3:5 concrete made with Atlas Portland cement. This was mixed in two Chicago concrete mixing machines located at the Broadway and Trinity Place ends of the lot, which delivered to steel buckets transported by flat cars on 24-in. Koppel industrial tracks running from end to end of the lot and serving all of the derrick booms.

Air was first admitted to the caissons June 20, 1906, and 60 days later it was removed from the last of the 87 caissons. As many as fourteen caissons were under pressure simultaneously, and 57 were sunk in 30 days at a maximum speed of as much as 2 ft. per hour, thus establishing a new record for rapidity in such work.

While the caissons were being sunk, three columns of the Sixth Ave. elevated railroad structure were shored up by the railway company on wooden piers, carried by transverse girders on longitudinal timber bents far enough apart to permit excavation to be completed and the new foundations built under them. The new concrete piers had foundations of steel piles jetted down and filled with concrete.

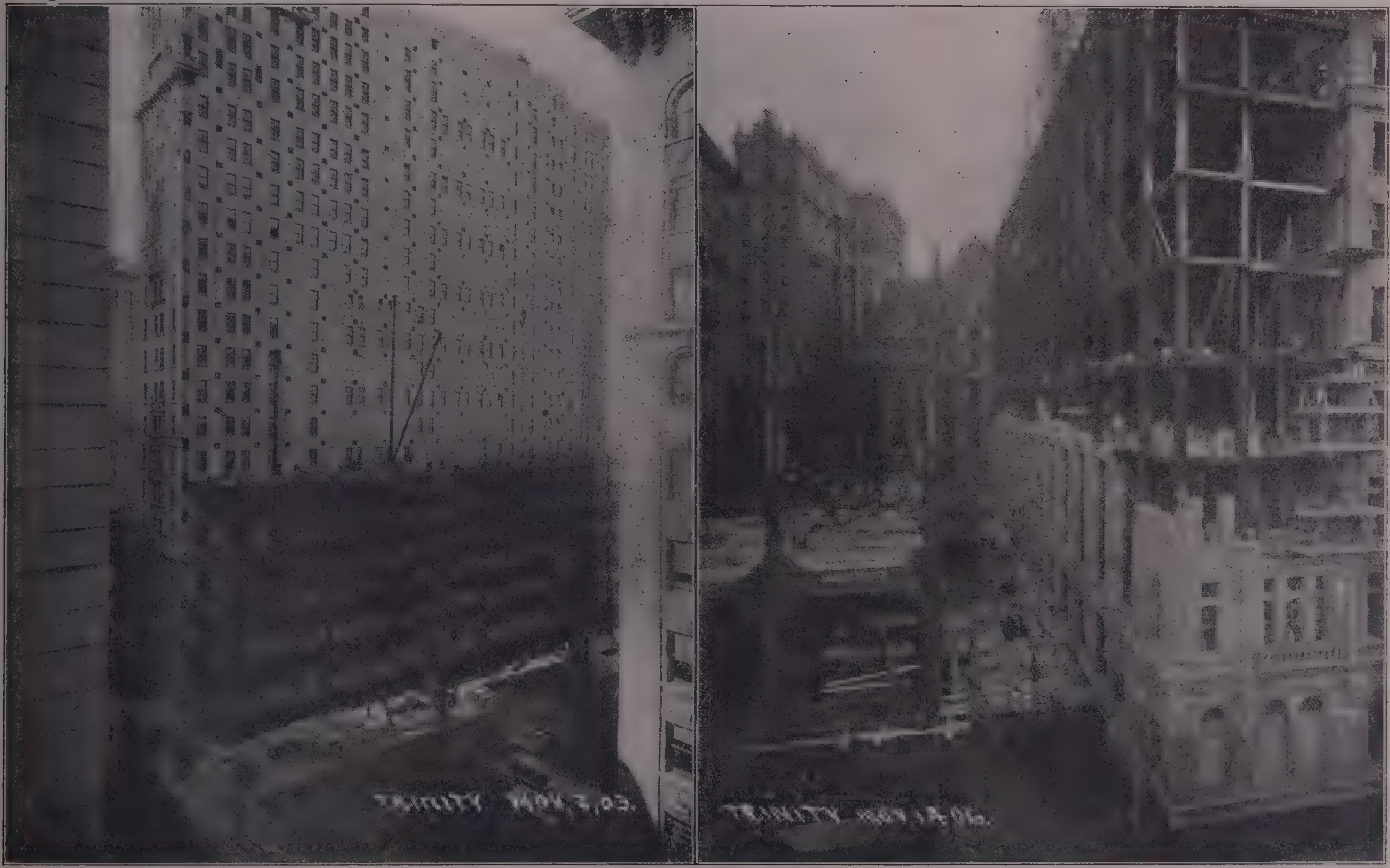
The main wagon platform was located between two rows of caissons, clearing them, and most of the space beneath it was occupied by wooden houses for the accommodation of the men and for the different shops and storage rooms required by the work. Several small movable wooden office buildings were provided for the superintendents, inspectors and foremen, and were moved from place to place by the derrick booms as required to clear the caisson sinking or other work in progress. The stubstructure work was executed by a total force of about 850 men, divided into three shifts to maintain the work day and night and organized under mechanical, pneumatic and general divisions.

The superstructure contains about 8,000 tons of structural steel and is of standard steel-cage fireproof design with a very simple arrangement of columns having a closed rectangular cross-section made of pairs of channels and cover plates, and with ordinary I-beams and girders connected to them with angle brackets and field-riveted web connections. All exterior columns are enclosed in the masonry, and the interior ones are enclosed in hollow tile casings, all of them being built solid and slushed with mortar to avoid air spaces. Beams and girders are fireproofed with hollow tile and the floors are all of hollow tile flat arches aggregating about 553,000 sq. ft., furnished by the National Fireproofing Co., which also supplied 4, 5 and 6-in. hollow terra-cotta tiles for the partitions. All windows in the toilet rooms and in the elevator fronts are glazed with wire glass, all sash and doors are kalamined, all other wood used in the building is from the American Fireproofing Co. The exterior walls are of brick faced with granite from the New England Granite Co., and with limestone furnished by Wm. Bradley & Son.

After the completion of the substructure work the derrick towers and other items of the plant were removed and the erection of the superstructure was commenced by the general contractor, who installed eight derricks arranged equidistantly in two longitudinal rows, four derricks in each being located so as to interlock with each other and command the entire area of the lot as well as the street fronts, thus enabling materials to be unloaded directly from wagons and set in the required positions without repeated handling. Each derrick had a 75-ft. mast and a 65-ft., 25-ton boom rigged with five-part tackles of ⅝-in. plough steel and guyed with seven 1⅛-in. steel rope guys adjustably connected to the beams and columns with clamps and steamboat ratchets. They were operated by Mundy hoisting engines provided with independent steam boilers. The derricks were moved from floor to floor at every second tier as the erection progressed, being handled in the usual manner by disconnecting the booms and using mast and boom successively as gin poles to handle each other. The entire operation of moving and re-installing a derrick required the service of eight men and put the derrick out of service for an average of four hours.

Lead pans were set on top of the concrete piers to receive the grillage beams; their sides were flashed up over the column pedestals and connected with the tar and felt laid on the cellar floor to make the water-proofing continuous and prevent leaks at the columns. An arrangement has been made by which the lead pans may be connected with copper wires running to a copper anchor plate in order to prevent electrolysis. The cast steel column bases were very carefully placed with level and transit, were adjusted to the exact height with iron wedges and were grouted with Atlas Portland cement.

On account of the great amount of traffic in the congested street and the small space available for storage, structural steel was delivered only as required for immediate use. It was drawn by trucks to Cedar and Thames Sts., where the drivers were directed by the distribution clerk to proceed to a given derrick, which removed their load and swung it at one operation to the point in the building where it was to be erected, often assembling the column in position without removing the slings. Where a number of beams and girders were hoisted at once, they were deposited on the upper tier of beams near their required position and afterwards assembled in place one by one. The erection was commenced Oct. 24, with an average force of about 240 men, and the work was carried on with unusual rapidity, four stories of the Trinity addition being erected in a single week. Each story weighed about 150 tons and comprised 19 columns. In the Realty Building the record speed was 2½ stories per week, each story having 72 columns and weighing about 600 tons.



Views Showing Holes in Wall of Old Trinity Building to Receive Ties to New Work, and Thames St. Platform.

The extension to the Trinity Building contains only a single row of columns and is made integral with the steel work in the structure previously completed. Provision was therefore required for connecting the beams and girders in the new part to the old part. This was accomplished by cutting holes through the wall of the old part of the building at every panel point. Swinging scaffolds were suspended from the roof of the building and from them holes were cut through the brickwork by hand. Open rivet holes had been provided in the original design of the steel work for the future connection of the members of the addition to the building, so that connections were ready for the new beams and girders as soon as the holes were cut.

All field connections in the steel work were made with ¾ and ⅞-in. rivets driven by 22 pneumatic hammers of the Chicago type. An electrically-driven air compressor was located under the sidewalk bridge on Thames St. and delivered air at an average pressure of 110 lb. to a 3-in. vertical pipe in the center of each building. It was provided with 2-in. branches on every floor from which distributing mains with outlets for flexible tubes were run as required to reach all parts of the structure. The steel fitted together well and a slight amount of reaming and drilling was done with four pneumatic reamers and four pneumatic drills, while a few holes were punched with a hand hydraulic machine. The rivets were driven at the rate of 300 to 400 daily by each of eighteen 4-man gangs.

A party of three men were constantly employed in plumbing the columns, and wherever one was found out of vertical, it was aligned by an adjustable wire rope diagonal attached to the floorbeams and columns of a lower story. This was done before the field connections were riveted and preserved the verticality so thoroughly that none of the columns were much more than ¼ in. out of plumb at the upper ends, nearly 300 ft. above their pedestals.

As it was inadmissible to use any portion of the street or sidewalk for storage purposes or to obstruct it seriously by trucks, most of the materials used were delivered inside the building on the wagon platforms already described for the substructure work or on Thames St., which, never an important thoroughfare, was, during the construction of the building, essentially a part of the structure. The space under the wagon platform on this street was vacated by the temporary houses used by the substructure contractors and was used chiefly for storage of piles of brick, broken stone, sand and cement, delivered through traps in the platform. These were the only materials which were stored in quantity at the site.

The limited space available and the necessity for simultaneous work on all floors as fast as they were erected, made it impossible to tolerate obstruction by storing materials, and great attention was given to perfecting a system to insure the delivery of materials exactly as they were needed in construction. The superintendent had made from the drawings elaborate bills of all items of structural material required. These were identified by reference marks on the drawings and on the bills, and a large force of clerks and inspectors were stationed at the different shops, mills and quarries and with the contractors supplying these materials and made daily reports of the exact amounts of materials completed and under way at different points. They were advised when to ship certain items and watch was kept over the latter to see that they progressed to the building without interruption after the shipment. In this way the required time in transit was accurately estimated and nothing but severe storms or accidents prevented the materials from arriving in the order and quantity needed for current use, not more than two or three days' supply of any materials being maintained at the site.

In the case of the cut stone, great quantities of which was shipped from New England by water, the irregularities and uncertainties were greater. On one occasion fear was entertained that the sailing vessels would be too slow and tugs were sent out and towed them the entire distance from Boston to New York. This system was so perfectly developed that the heavy January storm in which about 1 ft. of snow fell in New York City, which paralyzed traffic for several days and required the expenditure of nearly $1,000,000 for its removal, only delayed the cut-stone work two days.

About 85 wagon loads or 375 tons of cut stone were used daily during the construction of the exterior walls, the maximum record being 97 loads aggregating 500 tons. The total amount of cut stone used was about 260,000 cu. ft. and was delivered on the long sides of the building on Cedar and Thames Sts., where it was unloaded from the wagons and hoisted through holes cut in the elevated platforms.

Five derricks with 45-ft. booms operated by 8¼x10-in. double drum Lidgerwood steam hoisting engines were supported on the wall columns in the upper parts of the building, hoisted the stone from the wagons and delivered it to trucks on cantilever platforms called runs, projecting beyond the face of the building, one story above the places where the stone setters were at work. Each run was about 4 ft. wide and 6 ft. long, built of 3x12-in. planks 16 ft. long laid across the floorbeams and anchored at their inner ends by vertical braces to the floor above. The stones were deposited on two-wheel trucks, taken inside the building and distributed on working platforms to points just above where they were required. From here they were lowered to position and set by 65 breast derricks operated by hand windlasses.

The facing stones were anchored to each column by four sets in every story of bent rods 1 in. in diameter, five blacksmiths being continually employed in bending and fitting the anchors as required. Every stone over 2 ft. long was also secured by two 1¼x3/16-in. ashlar anchor straps 12 in. long, and every stone less than 2 ft. long was secured by a single anchor strap. The stones were bedded in 2:1 Lafarge cement mortar with ¼-in. bed and 3/16-in. vertical joints. The backs of all stones were painted as soon as set with one coat of antihydrine damp-proof paint and afterwards thoroughly flushed with cement mortar to the brickwork.

The stone was set, without the use of scaffolds, by the overhand method, by an average force of 150 men besides about 55 stone cutters employed on the job for finishing and special work, all the stone being cut and carved and about two-thirds of the granite being polished at he quarries. The stone work was commenced at the first story and carried up through successive stories to the roof, only one story being in progress at one time. The stone setters commenced work on the Trinity extension Oct. 30 and finished it in 62 days actual working time. They are now at work on the Realty Building.

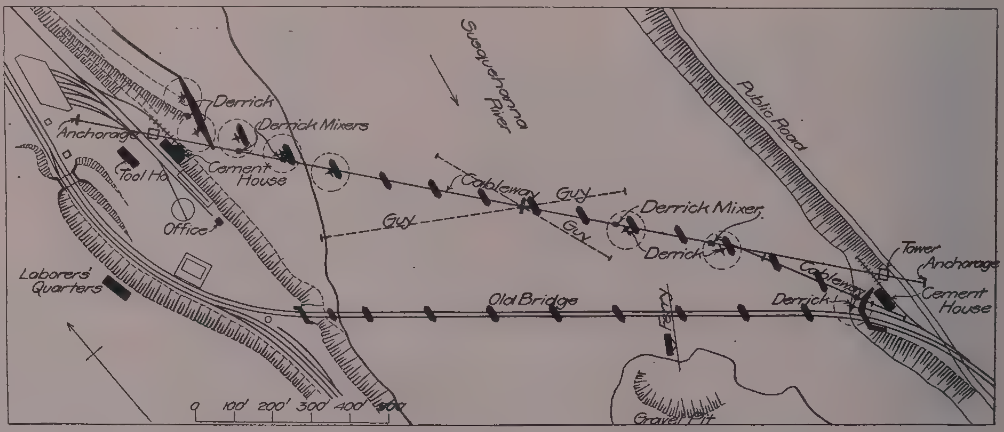
About 10,000,000 red brick are required in the building and were stored to some extent under the Thames St. platform and distributed as required on the different floors. Some of the bricks were hoisted from the wagons to the required position and those which were stored under the platform were delivered by wheelbarrows to ten Buckley hod hoists, operated by independent 5-h.-p. General Electric motors. Bricklaying was commenced Oct. 1 and carried on with an average force of about 225 men working single turn. The bricklaying was done from successive tiers of inside trestles, no outside scaffolds being used.

Eighteen holes, the longest of them 310 ft. deep, were drilled in the basement for the Standard plunger elevators with less than two months' actual work. The longest time required to drill any one hole was 51 days. The holes were made by driving a casing pipe to rock, the earth core being removed as the pipe was driven, care being taken to remove it exactly as the pipe was driven, neither faster nor slower, thus making the operation safe in the most treacherous soil. After the rock was encountered the holes were continued by a rotary drill, which removed cores of an average length of about 5 ft., the longest on this work being two of over 21 ft. After the holes were completed steel cylinders with stuffing boxes at the upper ends were lowered into them to receive the elevator plungers.

Construction of the hollow tile floor arches was commenced Nov. 1, by an average force of about 50 men, who completed the work in the Trinity Building Feb. 15. The tiles were laid in the usual manner on horizontal platforms of 2-in. plank supported by 4x4-in. timbers 8 ft. apart, suspended from the steel floorbeams and removed after the tiles were keyed and set.

The rough carpenter work in the buildings will require about 75,000 ft. B.M. of lumber. It was commenced on Nov. 1 and has been carried on continuously by an average force of about 200 men, followed by another force of 200 men, who commenced on Feb. 10 to set the trim. The plastering will amount to from 100,000 to 150,000 sq. yd. and is being done by a force of about 125 men. The total force now employed on the building is about 2,000 men working single shift except when it is necessary for a few employees to work until 10 p. m. hoisting heavy materials. Artificial illumination was provided by arc and incandescent lamps supplied by the Edison Co. Besides the plant already mentioned, the principal items installed on the work include twelve double-drum Lidgerwood and Mundy hoisting engines, one Cameron steam pump, one Brooks electric pump, one McKiernan and two Ingersoll-Sergeant air compressors used for the substructure work.

Mr. Francis H. Kimball is the architect and the George A. Fuller Co., Mr. A. M. Ganson, superintendent, is the general contractor. Mr. B. W. Green was the contractor for the removal of the old buildings, the Foundation Co. for foundations, Mr. William Angus for the stone setting, Mr. William Bradley and Mr. John Peirce for the stone work, the National Fireproofing Co. for the hollow tile, McNulty Bros. for the plastering and the Batavia Co. for the trim.



Arrangement of Contractor's Plant, Susquehanna Bridge.

General Excavation of Site, Trinity Building.

A Philadelphia Apartment House, eight stories and basement in height, and 40 x 127 ft. in plan, is being built with reinforced concrete frame and floors and plaster block partitions. The floor construction consists of reinforced beams 4 in. wide and 6 to 8 in. deep, spaced 16 in. center to center between the main girders, the whole being covered with a 2-in. floor slab reinforced with ¼-in. rods. As a flat ceiling was required a filler of plaster block was used. These blocks were 12 in. wide at the top and 11½ in. wide at the bottom and were made of the same depth as the beams between which they were to be placed. Each block is penetrated longitudinally by two core spaces. These blocks were laid on the wooden forms for the lower surface of the small cross beams and being properly spaced, the top and side surfaces of the blocks served as forms for the small floorbeams and floor slab. Being wedge-shaped, the blocks are held in place by the beams. Upon the forms being removed a smooth ceiling was revealed upon which, according to a paper by Mr. H. G. Persing, read before the Engineers' Club of Philadelphia, only a white coat of plaster was required. Plaster blocks were used for their good sound and heat insulating properties.

THE NEW LEHIGH VALLEY BRIDGE OVER THE SUSQUEHANNA RIVER, NEAR TOWANDA, PA.

This work, now nearing completion, is part of the most important improvements under way on the Lehigh Valley R. R. at the present time. It consists of changes in alignment and grades, between Wysox and Towanda, Pa., and a new bridge over the Susquehanna River, the entire work covering about 6½ miles. Numerous lines were projected and estimated on, notably several crossing the river into Towanda, with the idea of a more convenient location for a passenger station for the town; but the excessive cost of the crossing and of right of way caused the abandonment of the scheme, and the adoption of the line as built.

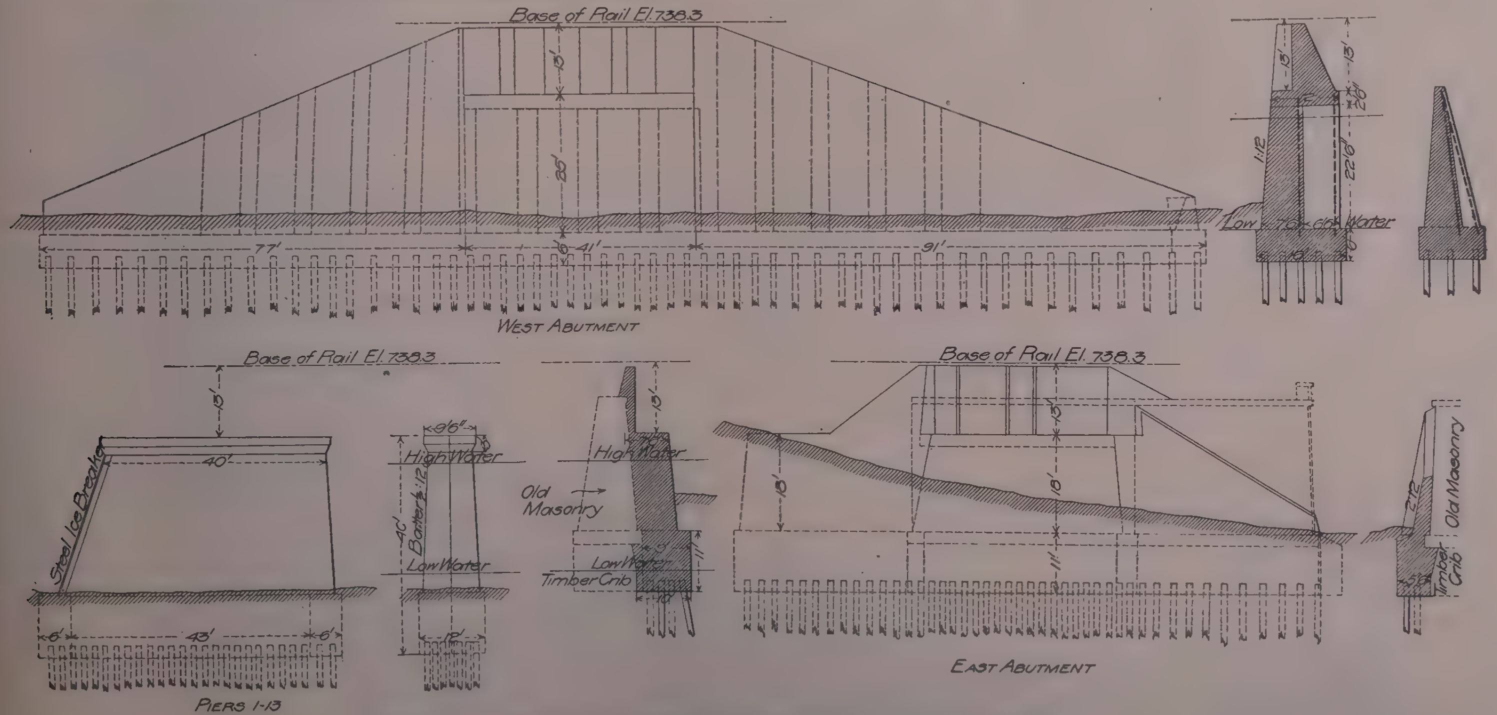
A—Frame for Lidgerwood Cableways.

The combination of grades and curvature on the present line between Towanda and Wysox make this section the limiting point for train loads on the engine run between Coxton and Sayre, Pa., for both east and west bound trains. The next limiting point on this division is at Vosburg Tunnel, where the conditions are such that there is but little opportunity for their betterment. It was therefore decided that if the grades and alinement between Towanda and Wysox were reduced to such an extent as to make Vosburg the limiting point for the engine run, the improvements would be ample.

Computations of the reduction in train mileage due to heavier trains that can be hauled over the revised line, including heavier motive power over the new bridge, further showed a capitalized annual saving in excess of the entire cost of the improvement, including the cost of the new bridge, which justified the outlay. Two very objectionable grade crossings are also eliminated, and a new station provided for Towanda.

The old masonry of the present bridge was built in 1865, the piers being sunk in the deep water of a dam located just below it. When the dam was subsequently carried out in 1874 it left these cribs exposed to the elements. The new bridge is built with 3° 30′ curves at each end in place of 7° 30′ curves in the old bridge, which limited the train tonnage. The piers of the new bridge are spaced closer than in the old bridge, so as to allow deck plate girders to be used in place of truss spans. The new bridge is being built with absolutely no interference with the operation of the road, which would not have been the case if the old structure had been remodeled, an important condition on a busy line.

The new bridge will consist of 14 spans of deck-plate girders, all of which are 129 ft. 6 in. long over all and 10 ft. 1½ in. high, except for the east span, where the spacings are odd owing to the different skew of the east abutment. The total length of the crossing is 1,801 ft. from abutment to abutment. The distance from base of rail to top of masonry is 13 ft., and the girders weigh ap-



Details of Piers and Abutments, Susquehanna River Bridge.

proximately 65 tons apiece. The girders are now being erected by the Phoenix Bridge Co., of Phoenixville, Pa., who have the contract for the steel work. They will be erected by a cantilever traveler without the use of falsework owing to the risk from highwater and ice at this season of the year.

The masonry consists of thirteen piers and two abutments, all of concrete, resting on piles, the details of which are shown in the accompanying diagram. The east abutment is faced against the north wing of the old east abutment. The thirteen piers are all of the same general design, the leading dimensions being shown in the figure.

The foundations were excavated by hand inside clay-puddled cofferdams to the specified depth below the river bed, after which the piles were driven in each foundation, and cut off 2 ft. above the bottom of the foundation. Oak piles were used throughout, and were driven with drop hammers. At first a water jet was used in driving; but it was found that the nature of the material, which consists of coarse gravel and sand, was not suited to the use of the jet and it was discontinued. Piles could be driven just as deep and more rapidly without the jet than with it, and with less disturbance to the material in the bottom of the foundation. After the piles were sawed off the foundation, pumps were stopped and the foundation concrete was then deposited through steel chutes of varying lengths. The pumping was unusually heavy in the pier foundations, as many as four 6-in. and 8-in. centrifugal pumps being used on a foundation owing to the large amount of water coming up through the bottom.

The west abutment is of reinforced steel construction. As shown in the diagrams the back of the abutment is pocketed and reinforced with ¾-in. steel rods. The high price of lumber and labor required to build the more complicated form necessary for this abutment probably counterbalanced the saving in concrete due to the pockets. The abutment also rests on piles and contains about 2,000 cu. yds. of concrete.

The concrete was mixed in Ransome mixers in the following proportions: Piers, including foundations, 1-2-4; abutment foundations, 1-3-6; abutment neat work, 1-2½-5, with the exception of the backwalls and coping, which were 1-2-4. River gravel was used throughout. Two pile-drivers, three mixers and six centrifugal pumps were required.

The contract for the masonry was awarded on April 4, 1906, preliminary and shore work was started April 15, but owing to high water the river work was not started until July 9. Notwithstanding these delays, the work was completed Oct. 29, 1906, which was over a month before the expiration of the date for completion of the contract. In other words, the eleven river piers were completed in less than four months.

The plant used in constructing the masonry is of especial interest, particularly the novel use of the double-span Lidgerwood cableway. In order to complete the work within the required time, a large plant was required to take advantage of the short working season of low water, and all preliminary work possible was done so that the plant would be ready when the river was favorable for foundation work. The general layout of the plant is shown in the figure. Three cableways supplemented by derricks were employed. The main cableways consisted of a double Lidgerwood plant of 1,000 ft. span each, supported on the shore ends by 80-ft. towers containing the machinery and in the center by a 75-ft. A-frame tail tower on pile bents, guyed in four directions. This double cableway was designed for a working load of 3 tons, with an occasional overload of 7 tons, which was sufficient to pick up and set mixers, pile-drivers and hoisting engines, in addition to regularly hauling concrete and other materials. A track was located under each cable at the shore towers so that machinery could be handled directly from railroad cars.

A smaller cableway, of 500-ft. span, was used to build the east abutment and piers 1 and 2 (on the east curve), and the west abutment and piers 11, 12 and 13 (on the west curve) were built with derricks. This arrangement of the plant made it possible to carry on the work constantly at four independent points.

The plant in the river was blocked up sufficiently high and guyed to provide for an ordinary summer raise in the river. The A tower was guyed rigidly in four directions in order to prevent the vibration of one side of the cable being transmitted to the other and interfering with the independent operation of the two plants. The entire work proved to be well suited for cableway construction, and it is doubtful whether any different equipment would have done the work within the time without considerable additional expense.

The masonry and substructure work was done under contract by S. B. Mutchler & Co., of Phillipsburg, N. J. The improvements are being carried out under the direction of Walter G. Berg, chief engineer; F. E. Schall, bridge engineer, and E. H. Shipman, assistant engineer, Lehigh Valley R. R.

Lidgerwood Tower, Piers and Derrick on East Bank of River.

Boiler Explosion Laws.

The Hartford Steam Boiler Inspection & Insurance Co. has several times traced boiler explosions to lap-joint cracks under the outer edge of rivet heads in a position where the most careful inspection cannot detect them. In consequence a number of people, some of them prominent engineers, have suggested that the use of the lap seam be absolutely prohibited by law, the butt joint, which apparently is not liable to similar cracks, being required in its place. The Hartford company considers this a rather drastic proposition, and has commented on it as follows: "We should like to see the lap seam discarded altogether, for boilers carrying considerable pressures; but we are aware, at the same tim ,ethat the lap joint is regarded by many as entirely satisfactory, when it is well designed and well constructed. At all events, designers of admitted ability continue to make use of it, as they would not do if they were satisfied that it was markedly dangerous. It is probable that 80 per cent. of all the boilers now in use in the United States have lap joints; and the proposition to make the further use of these boilers illegal strikes us as calling for the most serious consideration before acceptance. Certainly there never has been (so far as we are aware) any municipality or state or government, nor any bureau of steam engineering, which has yet made any permanent, wholesale and unqualified condemnation of the lap joint. In view of these facts it is certainly reasonable to suggest that the matter be most carefully considered before manufacturers and boiler owners generally are put to the enormous expense and inconvenience that would be involved in prohibiting, at once, the use of lap joint boilers. We are not here pleading for the continued use of the lap joint, but only for reasonableness in any legal enactments that may be contemplated by the legislators of the country."

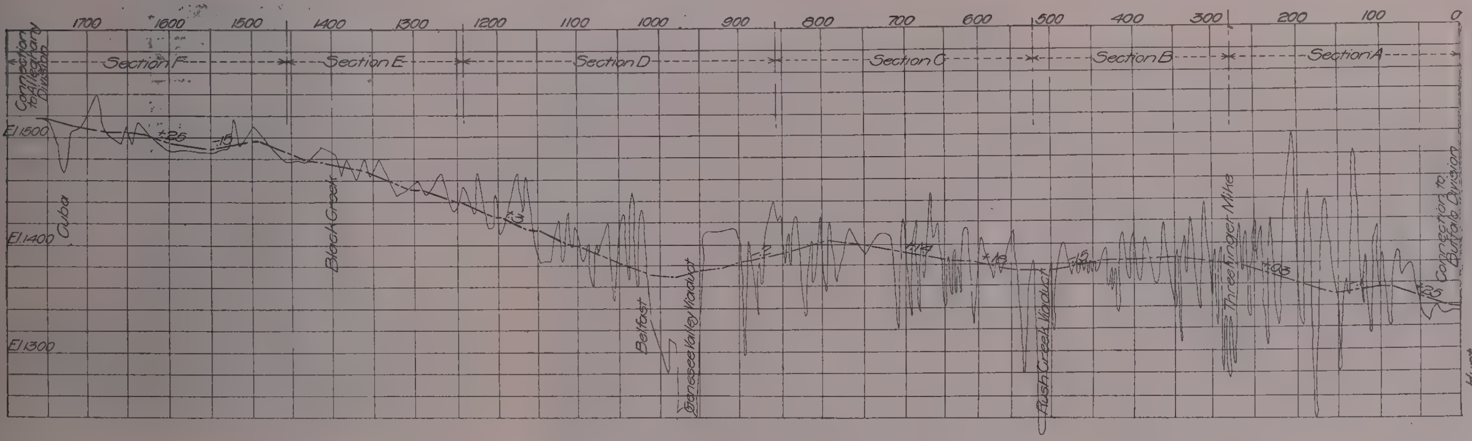
An Air Receiver Explosion in Lumaghi mine No. 2, at Collinsville, Ill., on Feb. 2, seems to have been due to the pressure of oil in the receiver, which has been the cause of a number of such accidents.

THE GENESEE RIVER CUT-OFF OF THE ERIE RAILROAD.

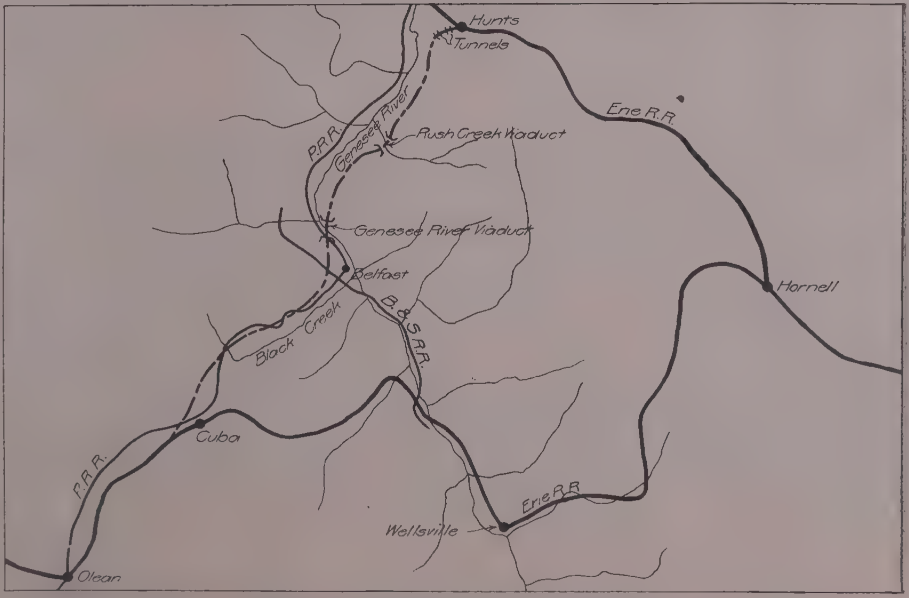
The Genesee River R. R., which is being built in southwestern New York by the Erie R. R., is a cut-off between Hunts, on the Buffalo division of the Erie, and Cuba, on the Allegheny division, which will give when finished a low-grade line between Hornell and Cuba. At present, the maximum grades between these points are 1 per cent. in both directions and necessitate the use of pusher engines. On the new line, the maximum grades will be 0.2 per cent. east bound and 0.3 per cent. west bound. The maximum curvature will be 3 deg., but only one 3-deg. curve occurs and with the exception of it and three others of 2 deg. 30 min., 2 deg. and 1 deg. 45 min., curvature respectively, the rate will not exceed 1 deg. and 30 min. The new line is 32.91 miles long, the distance betwen Cuba and Hornell by way of Hunts being 6.7 miles longer than over the present route. The new road takes its name from the Genesee River which it follows about 15 miles, as shown on an accompanying sketch map. Above the first bank of the river is a second bench behind which are the hill tops along the valley. The line has been located in general on this secondary bench. The preliminary surveys were begun in 1904 and over a year was spent on the final location of the line, and the result is that a line with very moderate grades has been secured, on which the cuts and fills are balanced very satisfactorily.

A Run-Around at the Oil Creek Culvert Site.

The construction of the Genesee River R. R. involves the excavation of 3,700,000 cu. yd. of material ranging from blue clay and shale rock to sand and gravel, including the driving of two tunnels with a combined length of 2,200 ft. Over 86,000 cu. yd. of concrete will be required and about 6,000 tons of bridge material. At present the line is to be single track, but the tunnels and all masonry and steel bridges will be made wide enough for two tracks, and the grade line has been located so that embankments and cuts may be widened for a second track without interfering seriously with traffic. The standard roadbed is 23 ft. wide in cuts and 19 ft. in fills. The track will be laid with 90-lb. rail and gravel ballast. Wherever possible, concrete arch bridges have been used and for small waterways concrete culverts and cast-iron pipe is employed. No wooden structures are used.



Profile of Genesee River Railroad.

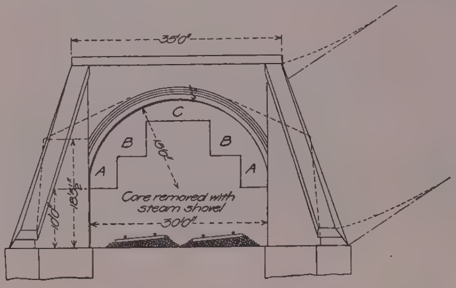


Map of Genesee River Railroad.

In letting the contracts for the earth work, the line was divided into six sections lettered from A to F, beginning at Hunts. Secton A extends from station zero at the junction of the Buffalo division to station 278. In this section there is about 1,100,000 cu. yd. of earth work, including 2,200 lin. ft. of tunnel and 14,000 cu. yd. of concrete masonry. The order in which the cuts, fills, tunnels and viaducts occur is shown on the accompanying profile together with the general grades. From station zero to 92, the work is being handled with a 70-ton Bucyrus shovel and four-yard cars supplied by the Standard Supply & Equipment Co. These cars are used exclusively on sections A, B, C and D, about 300 of them being on the work. The first or Genesee tunnel begins at station 122 and continues on a 2-deg. and 30-min. curve and on a westbound down grade of 0.1 per cent. to station 133. This tunnel, upon which work has recently been commenced, will be 30 ft. wide between the concrete side walls, which are 10 ft. high, and will have a semi-circular five-course brick arch ring. It is to be driven from the west end and the work will be carried on by first taking out by hand a top heading, of about the form shown in an accompanying sketch of the tunnel section, and later removing the core with a 45-ton special Model A Marion shovel, designed for tunnel work. The portions marked A are to be kept about 20 ft. ahead of B and C. The arch timbering will be supported on 12 x 12-in. wall plate timbers which are to rest on the earth till the core excavation begins when they will be supported as rapidly as possible on timber posts. The tunnel portals will be of concrete, and owing to the nature of the excavated material they will be U-shaped.

Leaving the Genesee tunnel, the line, continuing on a 0.1 per cent. down grade, crosses successively a small thorough cut and a 91,000-yd. fill and then changing to a 0.22 per cent. rising grade enters a thorough cut of 263,000 cu. yd. between stations 155 and 169. The material in this cut is sand and gravel with some clay and it is being handled with a 70-ton Bucyrus shovel and placed in a fill from station 170 to 182 by a series of switchbacks similar to those shown in an accompanying illustration. The vertical distance from the upper slopes at the top of the cut to the bottom slopes of the fill is 300 ft. At several points on the line where deep fills occur switchback and cable-hoist systems are being or will be used. At station 199, the Seneca tunnel begins and continues, on a tangent and a westbound up grade of 0.3 per cent., through 1,100 ft. of tough blue clay which when wet takes a slope of 2½ to 1. Wet winter weather has necessitated stopping the work here. The second or Seneca tunnel will be constructed in a manner similar to the Genesee tunnel and a special Model A Marion shovel will also be used here. This tunnel will be driven from its east end and the two tunnel shovels will be operated with compressed air, piped from a compressor plant located mid-way between the two tunnels.

Near station 270, the line crosses three converging draws, shown on the profile, and called "Three Finger Mike." The water running in these draws is to be collected and carried under the embankment through a concrete culvert with a 10-ft. semi-circular arch ring and 6-ft. vertical side walls. This involves a channel change of about 35,000 cu. yd., which is being made with a Page and Schnable scraper bucket operated with a stiff-leg derrick having a 60-ft. boom. The channel change is made by cutting through the two banks, which separate the three draws, on a line nearly parallel to the embankment. A berm with a minimum width of 20 ft. is left between the top of the channel cut and the footing of the embankment, and the derrick is so placed that the material taken from the channel is thrown directly into the embankment. The material is blue clay with occasional boulders which are broken up by blasting, and the work is made difficult owing to the wet and sliding character of the material. Two 70-ton Bucyrus shovels are working near the west end of Section A.



Genesee Tunnel Portal.

Little Rush Creek 14-ft. Arch, 280-ft. Barrel.

The earth work in Section B, which extends from station 278 to station 520, aggregates 379,000 cu. yd. and there is about 12,000 cu. yd. of concrete. The line throughout this section skirts along the rise from the river bank proper to the secondary bench, which is about 200 ft. above the water. This rise is broken up by deep ravines, which necessitate a succession of short cuts and fills.

One 60-ton Marion shovel is at work in Section B. The locomotive equipment in use in the first two sections consists of three 12-ton Dixons and three 12-ton Vulcans.

At the west end of Section B, the line crosses Rush Creek Valley over a viaduct 1,900 ft. long with a maximum height of 160 ft. above the water. The structure requires 2,253 tons of metal and 4,500 cu. yd. of concrete, and is made up of alternate 40-ft. and 80-ft. deck plate-girder spans, supported, between the two concrete abutments, on steel towers resting on concrete pedestals. Each of the 40-ft. spans is supported by a tower and the 80-ft. girders span the intervening spaces. The towers and abutments are designed to carry two tracks though, at present, girders for only one track are to be placed.

Section C extends from station 520 to station 855 and contains about 581,000 cu. yd. of earth work and nearly 11,900 cu. yd. of concrete. Near the east end of this section a little way beyond the west abutment of the Rush Creek Viaduct little Rush Creek is to be carried under the embankment through a 14-ft. concrete arch with a barrel 280 ft. long. The embankment here is being made with material taken from a thorough cut between stations 537 and 560, in which quicksand has been encountered just above the grade line, in such quantity that it has been impossible to operate a steam shovel. The contractors are now planning to handle this cut with a Page & Schnable excavator and remove the material in the usual manner with 4-yd. cars and dinkeys. A 70-ton Bucyrus shovel is at work on this section and the material is being deposited in the fill, through a trestle, by means of a Mundy double-cylinder, double-drum hoist, which hauls three 4-yd. cars at once on a 12 per cent. grade. From station 560 to the end of Section C. there is a series of heavy cuts and fills, but no features of special interest, except near station 795, where Shango Creek is carried under an embankment with a 14-ft. concrete arch, and less than 100 ft. further west, a highway crosses under the new line through a 16-ft. concrete arch. In connection with the steam shovels working in this section, three Dixon locomotives are used. It is planned to put two additional steam-shovel outfits on this section in the spring.

Section D, extending from station 855 to station 1242, contains 1,400,000 cu. yd. of earth work and approximately 34,000 cu. yd. of concrete. In this section, the line crosses the Genesee Valley over a viaduct 3,120 ft. long with a maximum height of 135 ft. above the river. The east approach is on a 3-deg. curve through a thorough cut nearly a mile long, containing 286,000 cu. yd. of material. The west approach is made by a fill 3,300 ft. long, containing 1,050,000 cu. yd. Near the west end of this fill, the line is carried over the Buffalo and Susquehanna R. R. by a through girder bridge. About 600 ft. east of this bridge a public highway passes under the fill through a 16-ft. concrete arch, adjoining which, on the west side, is a 6-ft. arch intended to carry drainage water. The Pennsylvania R. R. also crosses under the west approach about 775 ft. from the west abutment, through a 33-ft. concrete arch on a skew of 49 deg. 42 min., with a barrel 226 ft. long. The total quantity of concrete in this structure is 8,500 cu. yd.

West Abutment, Genesee River Viaduct.

About 685,000 cu. yd. of material for the approach fill is being hauled from the west and the balance will be hauled from the east across the viaduct after it is completed. The material from the west is brought in by tracks laid around the hills and by means of switchbacks, the maximum haul being 4 miles. The fill, which has a height of about 80 ft. for one-third of its length, will be made by means of trestles and will be carried up in about 40-ft. lifts. The material brought across the river after the viaduct is completed, will be deposited between the west abutment and the Pennsylvania R. R. arch. The cuts west of the river in Section D are largely in shale rock. This is handled with steam shovels after being loosened with black powder. Star well-drilling outfits are used in making the blast holes, which are drilled from the top of the cut to within a few feet of grade and range in depth from 30 to 60 ft. Thirty or forty holes are shot at once. At present, there are at work in Section D, west of the river, one 70-ton Bucyrus and one 60-ton Marion shovel. In the spring, another shovel will be started west of the river and two on the east side in this section. With these steam shovels are used three 20-ton and three 12-ton Porter locomotives and three 12-ton Dixons.

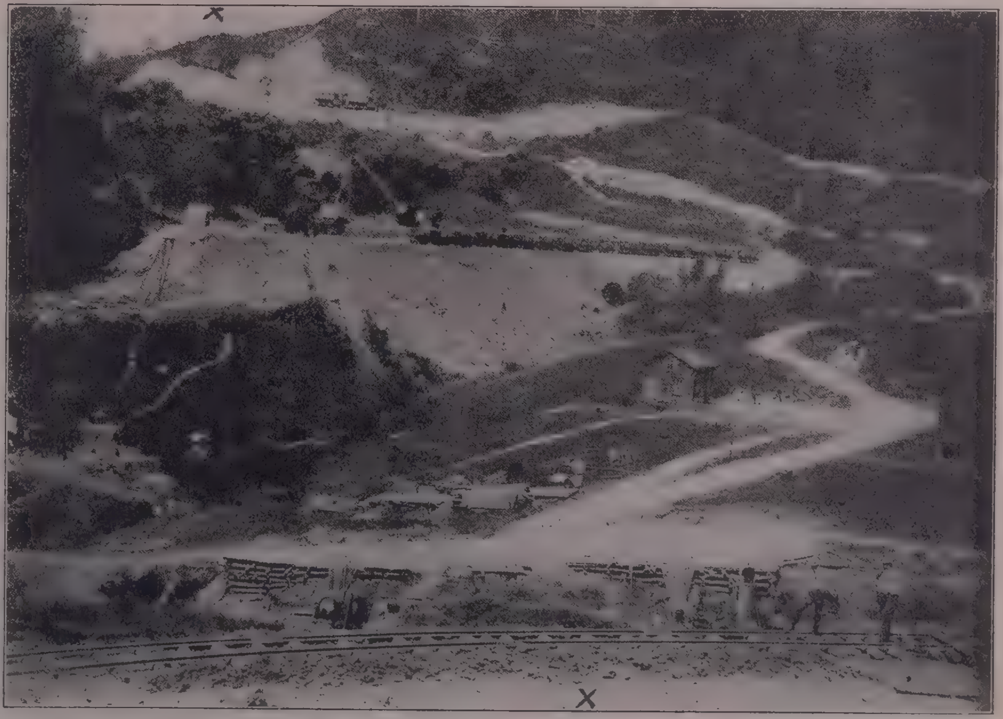
The Genesee River viaduct is made up of alternate 40-ft. and 80-ft. deck plate-girder spans supported on towers resting on concrete pedestals, except at the river crossing, where there are two

120-ft. deck plate-girder spans, carried at the center of the stream by a steel tower about 100 ft. high resting on a concrete pier founded on piles. The Genesee River Viaduct requires about 3,600 tons of metal and 11,000 cu. yd. of concrete. Of this concrete 1,299 cu. yd. is used in the west abutment, which is shown as completed in an illustration. It is 66 ft. high from the neat line to the bridge seat and its base is 36 x 22 ft. in plan. The earth of the approach fill will practically surround this abutment. The concrete work of this viaduct is nearly completed and the erection of the steel work will begin soon.

The West Approach Fill of the Genesee River Viaduct.

The lightest of the six sections is E, which extends from station 1,242 to station 1,456, and contains 100,000 cu. yd. of earth work and 2,500 yd. of concrete. In this section the line follows the general course of the Black Creek Valley, through which at one time ran the Genesee Valley Canal, which was operated between Olean and Rochester. The canal was abandoned and a right to construct and maintain a railroad on the canal banks was sold to the Genesee Valley Canal R. R. Co. about twenty-five years ago. Subsequently this company sold its right to the Western New York & Pennsylvania R. R. Co., who in turn leased to the Pennsylvania R. R. Co., which company now operates the line as its Rochester division. It follows in most instances along the tow path of the old canal and in its present location crosses and recrosses the line of the Genesee River R. R. twice. Changes are to be made by the Erie R. R., in the location of the Pennsylvania line, which will eliminate four of these crossings and cause the two roads to run on the same embankment for a considerable distance. The State Canal Commission in selling the right to the old canal to the Genesee Valley Canal R. R. Co., reserved the right to keep and maintain a waterway from Cuba Lake reservoir to Rockville reservoir, a distance of about eight miles, as a feeder to the Erie Canal. This waterway, which has been kept up by the State, parallels Black Creek. Permission has been requested of the State to divert the water, flowing in the canal, into Black Creek through which it would ultimately reach the same point and thereby save numerous bridges across the old canal. In both sections E and F numerous channel changes of Black Creek are being made, each of which involves 7,000 to 20,000 cu. yd. of earth work.

The earth work in section F, which extends from station 1456 to station 1757, the latter being the point of connection with the Allegheny division of the Erie R. R., 1½ miles west of Cuba, contains 295,000 cu. yd. of earthwork and 12,000 cu. yd. of concrete. The work is comparatively light, with the exception of about two miles at the west end, where there is a thorough cut of 115,400 cu. yd and a fill of 194,900 cu. yd. over Oil Creek Valley. This creek is carried under the embankment through a 40-ft. concrete arch, the site of which is shown in an accompanying illustration. The excavation here is being handled with two Marion shovels, a 60-ton and a 40-ton. East of this arch, about 2,200 ft., a highway is carried under the line through an opening crossed with a 16-ft. rail span with an adjoining opening crossed with a 6-ft. similar span, for drainage water. At station 1737, the Pennsylvania R. R. is crossed with a 65-ft. skew plate girder span, the skew angle being 34 deg. 7 min., and at station 1743 the state road from Cuba to Olean is carried under by a 16-ft. rail span with a 6-ft. arch for drainage water.



Making a Fill with Switch-Backs.

About four miles from the junction with the main line at Cuba, the Genesee River R. R. crosses Baldwin Swamp for a distance of about 3,000 ft. (Sta. 1530-1560). The average height of embankment required here is less than 8 ft. above the surface of the swamp. The muck in the swamp is 10 to 50 ft. deep and when about 8 ft. of embankment has been deposited, the crust breaks and the newly made fill sinks to the bottom of the swamp, leaving a trench which is at once filled with water and mud. In one instance, the embankment settled so quickly that within one-half hour after the crust broke 150 ft. of track had been lost in 15 ft. of water. Piles are now being used to stiffen the muck so that it will settle only as rapidly as the embankment rises. It is expected that the embankment will finally rest on the solid bottom of the swamp.

The general contracts for the Genesee River R. R. are dated June 20, 1906, and call for completion Dec. 31, 1907. At present about 900 men are employed on sections A, B, C and D, and in the early spring this number will be doubled. Contracts for earth work were let at unclassified prices and clearing and grubbing is included in the price paid per cubic yard. The engineering corps employed by the Erie R. R. on this work at present numbers over twenty-five men. The difficulty of carrying on the contract work has been greatly increased by its inaccessibility. All equipment in sections A, B, C and D, has to be taken in from one end or the other or from the Pennsylvania R. R. across the Genesee River and up the hill. The time required to install a shovel after it arrives at its destination averages from four to six weeks. In one instance, a shovel was moved across country eight miles by its own power on track laid in front of it and taken up behind. The maximum move was about one mile in 24 hr. In another case a large shovel had been brought up a steep clay hill till it was nearly at the top, when the track slipped on wet clay and the shovel slid to the bottom. Some of the small rolling stock was brought in on a specially constructed truck which is capable of carrying a 15-ton locomotive. This truck was hauled along the public roads with two traction engines.

In connection with the concrete work along the line, both Smith and McKelvey mixers have been used and Lidgerwood and Mundy hoisting engines are employed for a variety of purposes.

The Genesee River cut-off was located and is being constructed under the direction of Mr. Francis Lee Stuart, chief engineer of the Erie R. R. Mr. Richard Mather, assistant engineer, was in charge of the location surveys and is now supervising the construction work in the field, his headquarters being at Cuba, N. Y. The contracts for the construction have been awarded as follows: Sections A, B, C and D, Millard Construction Co., of Philadelphia, Pa., whose work is under the immediate supervision of Mr. F. H. Stier, vice-president; Rush Creek viaduct, The American Bridge Co.; Genesee River viaduct, the steel work to McClintic-Marshall Construction Co., and the masonry to Smith McCormick Co., Easton, Pa.; section E, W. H. Coverdale & Co., New York, whose work is under the supervision of Mr. P. A. Robins; section F. Bennett & Smith, Wilkinsburg, Pa., under the supervision of Mr. M. H. Smith.

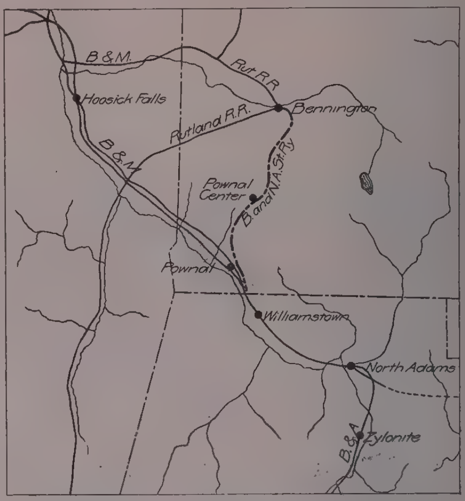
Resista Steel, so-called, containing 79 per cent. iron, 6 per cent. manganese and 15 per cent. nickel can be bent double cold, when cast in 2½-in. bars. When forged its tenacity averages 58 tons and it has the extraordinary elongation of 60 to 70 per cent. A singular fact regarding this alloy is that if either the manganese or the nickel is omitted, an extremely brittle product is the result.

The Construction of the Bennington & North Adams Street Railway.

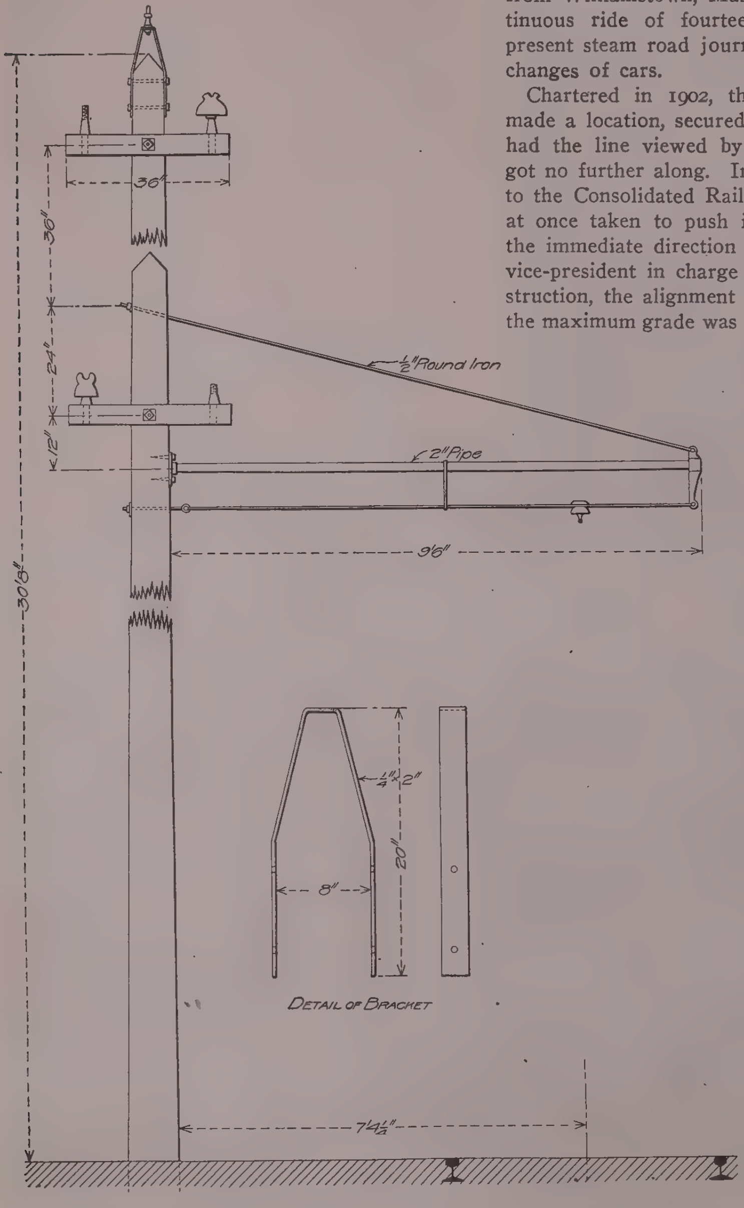
By Charles Rufus Harte, Assoc. M. Soc. C. E., Assistant Engineer, Consolidated Railway Co.

The Bennington & North Adams Street Railway—a misnomer, by the way, as it is of a thoroughly interurban type—extends from a connection with the Berkshire Street Railway System at the Massachusetts State Line, north 11 4/10 miles to connect with the tracks of the Bennington & Hoosick Valley Railway Co. at Bennington, Vt., closing the gap in the trolley lines between Great Barrington, Mass., and Hoosick Falls, N. Y., a distance of 82 miles, and offering to the traveler from Williamstown, Mass., to Bennington a continuous ride of fourteen miles as against the present steam road journey of 32 miles with two changes of cars.

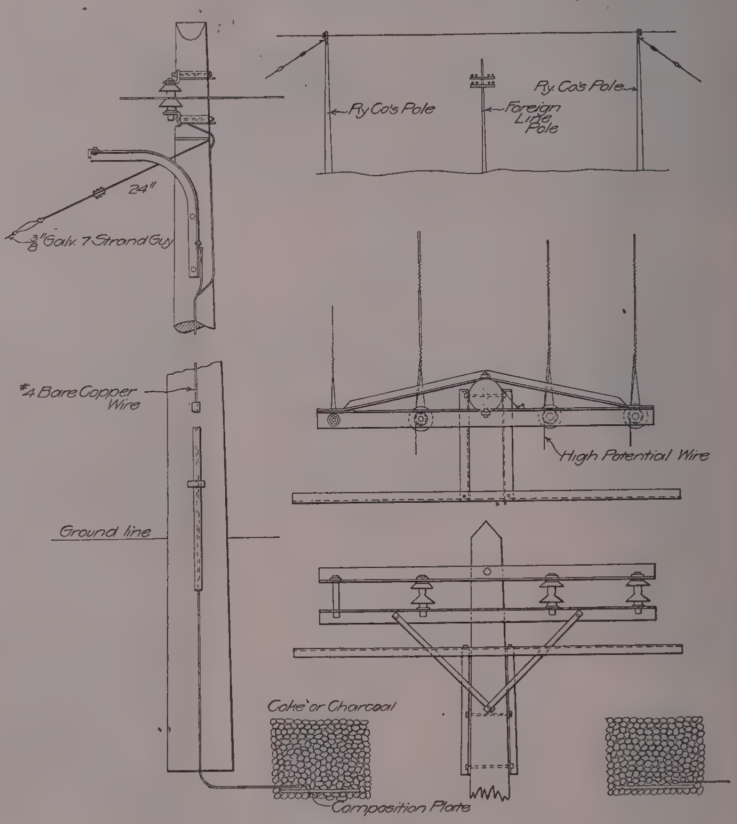
Chartered in 1902, the original incorporators made a location, secured some right of way, and had the line viewed by several contractors, but got no further along. In 1906 the control passed to the Consolidated Railway Co., and steps were at once taken to push it to completion. Under the immediate direction of Mr. E. H. McHenry, vice-president in charge of engineering and construction, the alignment was materially improved, the maximum grade was reduced from 11 per cent. to 3½ per cent., and on July 2, 1906, actual construction was begun, J. W. Daly & Co., then of Brewsters, N. Y., having the grading contract, C. W. Blakeslee & Sons, of New Haven, the track, and the M. B. Foster Co., of Boston, the bonding, transmission line and trolley overhead.



Bennington & North Adams Ry.



Trolley Construction with and without Transmission Line.



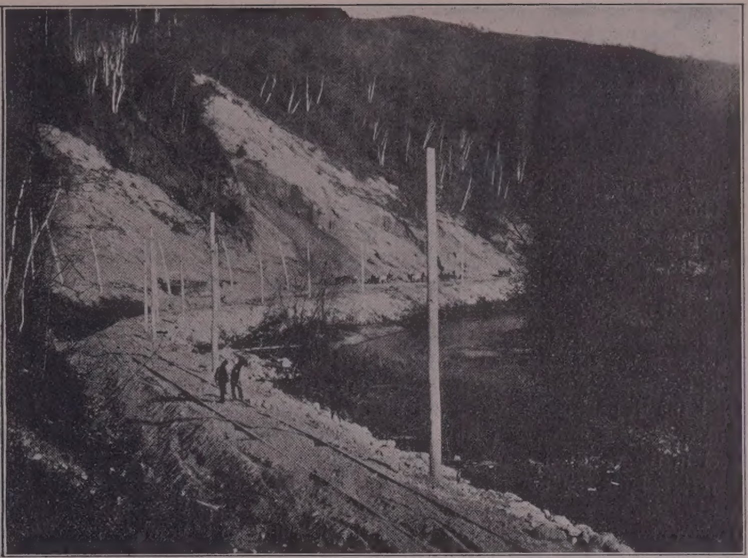
Details of Crossing of Foreign Line.

The charter called for operation on or before Dec. 1, 1906, giving but five months in which to move some 195,000 cu. yd. of earth and 90,000 cu. yd. of rock, not to mention bridges, track and overhead. Unfortunately no hope could be safely entertained of securing an extension of time, for a very general disbelief in the good faith of the old company, by no means lessened by the transfer of the property, had promptly attached to the new owners, and was certain to be reflected to at least some extent by the Legislature, which moreover did not sit until October. It was accordingly decided to take out the cuts to grade, leaving the side walls as straight as they would stand; to make the fills in layers continuous from end to end so track could be laid at any time, and at two critical points arrangements were made for temporary detours. The most interesting emergency arrangement, however, was that for power. It was the original intention to purchase alternating-current power from the Berkshire Street Ry., taking it from alternating-current generators, but it was seen that there was not time enough available.

At Zylonite, however, just south of North Adams, the Berkshire Co. had spare direct-current power. A rotary converter of 300 kw. capacity was here inverted, transforming the direct to alternating current, which would then be stepped up to the temporary line pressure of 11,000 volts; eventually the line will operate at double this potential. At Pownal Center a sub-station with two 200-kw. rotaries transforms back to direct current and feeds the line in both directions.

As is often the case in an emergency, everything seemed to conspire against the work. With a number of agents sending a steady stream of

A Typical Embankment.



Taking out Ballast at Dugway.

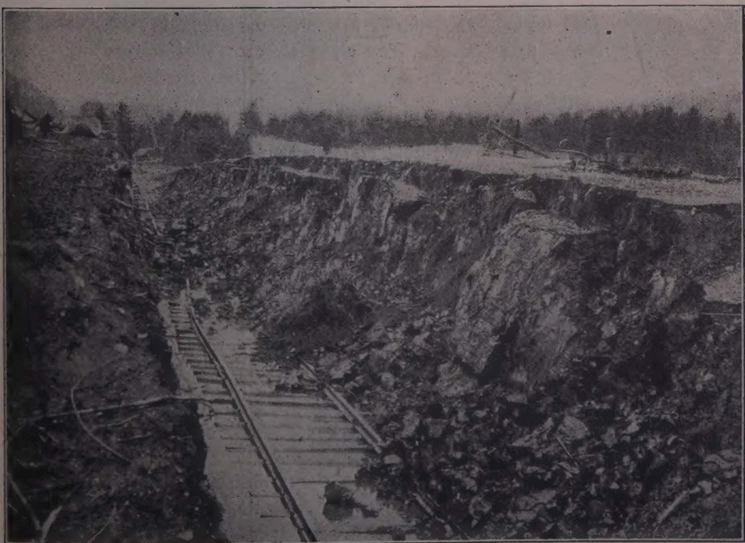
men to the shanties there was an equally extensive movement away, and it was impossible to maintain a working force in excess of 950, while the very general knowledge of the time limitation led to a series of most aggravating strikes and hold-ups. In one cut the steam shovel had seven different crews in less than a month, and twice during that time the machine was deliberately crippled, though fortunately not seriously, and at two strategic points, property owners dragged out negotiations for several months while just escaping condemnation proceedings. In spite of all drawbacks, however, the work advanced so well that at the sitting of the Legislature, there was no longer any question as to the company's sincerity and the time for operation was extended to July 1, 1907.

The energy with which the work had been pushed was in no way relaxed, but the method of attack was at once changed to meet the new conditions. Prior to the extension, operation by Dec. 1 was the one consideration, the work to be finished afterwards under traffic; the rearranged plans provide for the completion of the line before operation, which latter event will occur about the last of April.

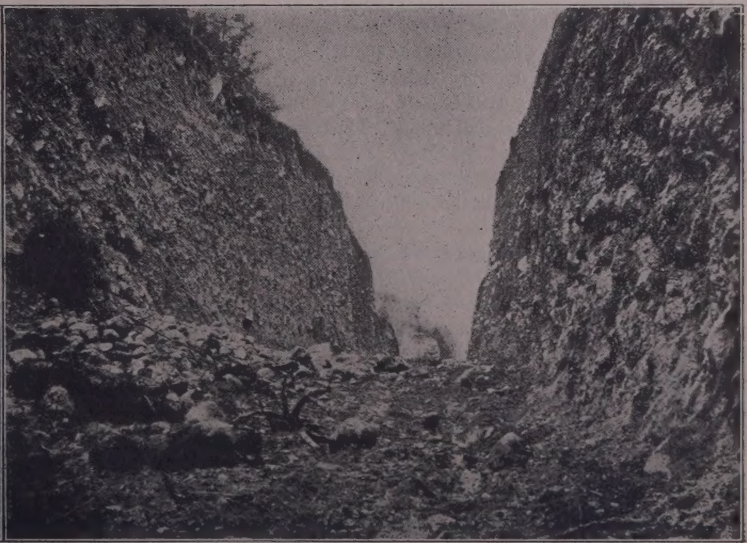
From the Massachusetts state line to Pownal, some 2½ miles, the track is chiefly along the highway, involving some heavy work in grading the latter to its profile, a condition of the location. A bench was first cut for the track, leaving a narrow road for teams. After the track was laid it was buried under gravel and traffic turned upon it while the remainder of the cut was made. The local conditions requiring the purchase of land for spoil, and the refusal of one man to sell a right of way for the transmission line—which is here away from the track—unless the entire parcel was taken, made it possible at the cost of this land to cut out some bad curvature, secure our pole rights, dispose of the spoil and by utilizing the old location for a turn-out track, avoid the purchase of an expensive piece of right-of-way.

Just north of Pownal begins a 3½ per cent. grade two miles long, which climbs the hillside to Pownal Center. The shaly rock met with was picked or blasted, depending on hardness, and in some cases was handled by steam shovel. There is a very fine view up and down the valley of the Hoosic River from this grade, for that matter from almost every point there is fine scenery. At the top of the grade and just below Pownal Center is the heaviest cut on the line, 1,400 ft. long and averaging 10 ft. deep in a hardpan but little easier to handle than rock when in place, but softening to a quicksand after being disturbed. This cut was worked from the lower end by a Little Giant traction steam shovel with bucket of 1⅛ yd. capacity. Contractors' locomotives bring the empties from the dump and take back the loaded cars, while a hoisting engine ahead of the shovel hauls up the empties one by one for loading, gravity running them back and overhauling the cable for the next car. It has been necessary to loosen practically all of this material by blasting, as the shovel although equipped with a powerful crowder engine can not otherwise work to advantage. Coming at a pass in the hills this cut is very wet, and there is little hope that the final slope can be maintained steeper than one on two. In addition to the shovel attack, the cut was worked at the upper end by teams, the material going largely to the approaches of two bridges by which highways at this point are carried over the track.

From Pownal Center the line runs on the east side of the valley of Jewel Brook, crossing a series of finger-like ridges and valleys, and giving an opportunity to work a large force to advantage. One of these ridges was of clay which, when first cut, seemed dry, and stood for some little time with a vertical wall. Eventually, however, it softened, and the resulting slip nearly filled the cut. Another ridge consisted of badly shattered limestone, the seams of which made much trouble in drilling. The usual treatment of fragments of cast iron in the hole was of little avail, owing to the size of the seams; in some cases these seams themselves were loaded and fired, but much of the work had to be done with shallow holes. The remainder of the ridges were of hardpan, drier than that at Pownal Center, but otherwise the same. The walls of these cuts could be depended upon to stand practically vertical, at least until frost left the ground, but it is probable that eventually they will come to a two to one slope. At present they are being cut somewhat steeper, but provi-



Slide Beginning in Clay Cut.



Hardpan Cut with Vertical Walls.

sion has been made for the sloughing expected.

The last mile of the line is very easy, and then, entering Bennington, the track lies on Beach Street for a few hundred feet, and then connects with the track of the Bennington & Hoosic Valley Co. on Main St., over which it has trackage rights to the center of the town, about half a mile from the Beach St. corner.

The bridges are almost entirely second-hand steam road bridges with concrete abutments, the body mixture of the latter being 1:3:5 with parapets and bridge seats of 1:2:4. No further attempts to secure a finish than by using tight forms were made, but the results are very good indeed. At the crossing of the Walloomsac River, just south of Bennington, no old span which filled the requirements was available, while the bridge companies were unable to furnish new steel in the required time. The abutments were therefore built for the new bridge as designed, and the gap then closed by a substantial pile trestle. When this latter requires renewal it will be replaced by the steel span.

The track is laid in 80-lb. Am. Soc. C. E. rail in 33-ft. lengths, with six-bolt angle bars, on standard steam road ties, spaced 2 ft. on centers, joint broken and suspended. Gravel ballast is used and is one of the serious problems of the line, the final solution being to haul it from the two extremes, the only places where any could be secured. A standard gauge tank compound locomotive, late of the Chicago Elevated, handles the two 9-car trains, and incidentally helps materially to compact ballast and fill. The gravel bank at the southerly end of the line adjoins the highway, and has annually caused much trouble from slides, the road at this point being known as the Dugway from the regular spring celebration. Use of material from this point therefore helped the town, if not the most desirable location for the supply.

The fourteen-mile transmission line from Zylonite consists of three No. 4 gauge copper conductors on a 35-ft. pole line almost entirely on private right of way, and incidentally almost every pole hole is in rock. From the state line, with the exception of one cut-off, the line is carried on the same poles as the trolley, and provisions have been made for its extension from Pownal Center to Bennington if desired later. The conductors form an equilateral triangle 32 in. on a side, a special roofing iron carrying the pole pin, the other pins being carried by a 40-in. cross arm. Triple petticoat chocolate-colored porcelain insulators similar to the C. S. Knowles "Redlands" type are used, on 11-in. pins.

At the crossings of highways, railways and other wire lines each conductor has the additional support of a ⅜-in. stranded steel cable to which it is tied every 4 ft., while a grounded arm of angle iron at each side of the crossing will cut off a broken wire in the adjacent spans before it can spring forward. The wires are given three transpositions in the length of the line, thus making a complete revolution. The entire line is heavily guyed and anchored, and extensive trimming rights have made possible considerably more than the proverbial ounce of prevention.

The overhead is bracket type, with 4/0 grooved trolley wires hung from pipe brackets 9½ ft. long, anchored at each end of every curve, and every thousand feet on long tangent. Bridle pull-offs are employed for curves, and for radii of 300 ft. or less span construction is used. Poles are spaced 110 ft. apart on tangents, and are 35 ft. long with 7-in. tip, provision being made for an extension of the transmission line when desired. The track has two 4/0 concealed bonds per joint, and is cross-bonded every 1,000 ft. with 4/0 cable.

The work has been carried out under the direction of Mr. E. H. McHenry, Messrs. Durkee, White & Towne, of Springfield, Mass., having the field engineering, the writer being in general charge.

The Terminal Warehouse of the Louisville & Nashville R. R. at Atlanta, Ga.

A five-story reinforced-concrete terminal warehouse, 50x836 ft. in plan, is just being completed for the Louisville & Nashville R. R. within two blocks of the central business district of Atlanta, Ga. This warehouse is a part of the extensive construction work that has been carried on by the Louisville & Nashville in the last two years to secure a direct freight route between Cincinnati and Atlanta. The route over which traffic between these cities was formerly handled by this road extended from Cincinnati by the way of Louisville, Ky., to Nashville, Tenn., and thence over the Nashville, Chattanooga & St. Louis Ry. to Atlanta. The Louisville & Nashville had a branch line which extended south into Kentucky from Cincinnati and was connected with Knoxville, Tenn., by an independent line, the Knoxville, La Follette & Jellico R. R. The Atlanta, Knoxville & Northern R. R., another independent line, extended from Knoxville to Marietta, Ga., a few miles from Atlanta. Both of the independent lines were acquired by the Louisville & Nashville, and the Atlanta, Knoxville & Northern was reconstructed for a considerable portion of its length, an entirely new road on a new location being built from Etowah, some distance south of Knoxville, to Cartersville, Ga., a point 48 miles west of Atlanta. These two roads, with the line already owned by the Louisville & Nashville, give the latter a direct through line over its own tracks from Cincinnati to Cartersville, its traffic being handled between Cartersville and Atlanta over the Western & Atlantic R. R.

The new warehouse will serve as a freight terminal for the new route and will also be utilized for storage purposes by patrons of the railroad. The first floor of the warehouse will be used exclusively for the freight business of the railroad. The upper four floors will be rented to merchandizing establishments requiring storage facilities. The building being only two blocks from the center of the city, it is well adapted for the business of such concerns, which will be required to handle their goods from a track along the side of the building into the latter only. Eight electrically-operated elevators, with a capacity of 8,000 lb. each, will be provided for handling freight between the various floors. The upper floors will be divided to suit the tenants and office rooms will be provided where necessary. The building has three longitudinal bays on all five floors, one 16 ft. 2 in. wide at the center, with a bay 16 ft. 11 in. wide on each side. The first floor is on a grade, the height of the first story varying from 14 to 18 ft. A steel viaduct, carrying Washington St., crosses the site near the middle of the building and for a width of 60 ft. the upper four stories are omitted.

The floor slabs are designed to carry a live load of 300 lb. per square foot and are 4¼ in. thick, not including a ½-in. finishing coat. They are reinforced parallel with the direction of the span with ⅜-in. square twisted steel bars, placed 8½ in. apart where the floor beams are 5 ft. 10¾ in. apart on centers, and with the same size bars placed 4½ in. apart where the floor beams are 6 ft. 10½ in. apart on centers. In the opposite direction to these ⅜-in. tension bars, ½-in. twisted square bars were placed about 18 in. apart on centers to provide against temperature stresses and shrinkage cracks.

The floor beams are carried by four longitudinal rows of columns, two rows in the interior of the building and one in each side wall. These columns are spaced 11 ft. 9½ in. apart on centers, longitudinally, except at the eight openings left for elevator shafts, where they are 13.75 ft. on centers. The soil at the site is a disintegrated granite that is difficult to excavate, is excellent foundation material capable of maintaining 10,000 lb. per square foot. The columns are on spread reinforced-concrete footings which are designed to bring a load of 2 tons per square foot on this soil. They vary from 22x22 in. in cross-section in the first story to 8x8 in. in the top story. The reinforcement of each column consists of four vertical steel rods, one in each corner, which are hooped with ¼-in. square bars placed horizontally, 12 in. apart on centers, the cross-section of the vertical rods being about 1 per cent of the cross-section of the column.

The walls of the building are reinforced-concrete slabs between the columns. The exterior girders of the frame of the building were not designed to carry floor loads, only enough steel being placed in them to carry the floors and walls during construction. Later the walls will act as girders carrying their own dead loads between the columns and a portion of the floor load. This result was accomplished by permitting stubs to extend out from the columns just above the floor levels, which stubs together with the steel in the temporary girders were sufficient to take the loads of the walls on the columns.

A track will be extended along one side of the building with its center line 6½ ft. from the wall line, so that no loading platform is provided and freight will be handled from the cars directly into the building, the first floor level being the same as the floors of cars on the track. An 8x8-ft. door opening is placed in the end of each transverse bay of the building in the side along this track. These door openings, of which there are sixty-six, have cast-iron jambs and sills and are fitted with Kinnear rolling steel doors. A roadway extends along the opposite side of the building and the same size door openings are placed in that wall of the latter so that trucks may be loaded readily from the first floor for making local deliveries.

A space, 26x50 ft. in plan, on the first floor and one 50x170 ft. in plan on the second floor at the front of the building are separated from the remainder of the latter by concrete and tile partitions and will be plastered and properly finished for the offices of the railroad employes and for file and record storage rooms. The interior surfaces of the walls and the surface of the columns in the remainder of the building will be left as the concrete comes from the forms. The exterior surfaces of the walls will be rubbed down and waterproofed. The floors in all five stories will be given a ½-in. granitoid finishing coat of mortar. A toilet room and four rooms for receiving clerks are also partitioned off on the first floor. The eight elevator shafts are each 8.25x13 ft. in plan in the clear, and in the office portions are enclosed in 6-in. concrete walls. Access may be obtained to the upper stories, when necessary, by eight sets of outside steel stairways supported on brackets cantilevered out from the frame of the building. These stairways are placed at regular intervals and entrance to the building is made from them through a door at each floor level.

The upper four stories are each approximately 11 ft. high in the clear. The second story has a pair of 3-ft. 2½-in. by 7-ft. window openings at both ends of each transverse bay of the building in the portion at the front set apart for offices. The remainder of this story and all of the three upper stories have a pair of 3 ft. by 4 ft. 1 in. window openings at both ends of each transverse bay of the building, except at the door openings provided for the stairways. All of these window openings have cast concrete sills and are fitted with metal frames carrying metal sashes glazed with wire glass. With the exception of the large windows in the office portion of the second floor, which have counterbalanced or double-hung sashes, and a few windows in the small office space on the first floor which have double-hung sashes, the sashes are all pivoted.

The power plant of the building will be placed in a basement 100 ft. long extending the width of the building immediately in the rear of the first floor offices. It will contain two electric generators each driven by a Skinner engine which will furnish power to operate the freight elevators. The main part of the building will not be heated at present, at least. The offices will be heated by exhaust steam from the engines.

No attempt has been made to produce an artistic exterior appearance for the building, but a cornice of concrete at the roof line, cast in moulds built up with the wall form, relieves any box-like appearance at that point. A large ornamental door entrance to the offices is also provided at the front of the building.

The roof consists of a concrete slab 2¾ in. thick, which is reinforced parallel with the span with ¼-in. twisted square bars, with ⅜-in. bars about 14 in. apart on centers in the opposite direction to provide for shrinkage. It is covered with seven-ply composition roofing laid in tar and finished with gravel. The roof is sloped to galvanized-iron downspouts along the sides of the building.

The details of the concrete design were made and the building was erected by the Ferro-Concrete Construction Co., of Cincinnati, O. Construction was started at one end of the building and carried through to the other end, one story at a time. The piers carrying the columns were first erected over the site, then the floor was laid, the columns in the first story built, the second floor laid and so on. Three Smith concrete mixers were set up at about equally spaced points in the building and were operated in connection with three 1-yd. Ransome concrete hoisting buckets in the spaces provided for elevator shafts. Two small boom derricks were used for hoisting reinforcing steel and lumber for forms, and were raised from floor to floor as the work progressed. The concrete materials, reinforcing steel and form lumber were delivered on cars on a track laid the length of the building at the first floor level. Enough forms for the columns, beams, girders and floor slabs of practically two entire stories were provided, and as the building is practically symmetrical they could be used the second time. The frame and floors of the building were completed before any work on the curtain walls was started. The latter were built in panels between the columns in the sides of the building, forms for 40 to 50 panels being provided. The surface of the 1:2:4 concrete of the floor slabs was left rough until the building was practically finished. It was then swept clean, washed with dilute hydrochloric acid and the ½ in. layer of cement mortar finish applied. This method of finishing is controlled by Mr. E. L. Ransome and has been used successfully by the Ferro-Concrete Construction Co. in a number of instances. The acid washes away the milky powder or efflorescence that forms on the surface of any mass of concrete laid wet and permits the new concrete or mortar to become bonded to the old. Floors finished in this manner upwards of two years ago have never given any evidence of the mortar cleaving from the concrete.

A 1:2:4 wet mixture of concrete was used in the columns, beams, girders and floor slabs, and a 1:3:6 wet mixture in the curtain walls. Southern States Portland cement was used exclusively. Crushed granite that would pass a 1½-in. screen was used for concrete, the entire run of the crusher under that size being used. When enough stone dust could not be secured sand obtained from several local sources was used.

The new warehouse was designed in the office of Mr. W. H. Courtenay, chief engineer of the Louisville & Nashville R. R.

Book Notes.

The importance of inland and ocean shipping is so great and so little information concerning it is readily available that Prof. Emory R. Johnson's "Ocean and Inland Water Transportation" is an unusually timely book. It supplements his book on American railway transportation published several years ago, and gives a fairly comprehensive outline of the methods of water transportation, the commercial forms required in making shipments, and the extent of water-borne commerce. While there are many books on the construction of vessels of all types, there are very few on the business done with their aid, and none other which gives so much information in a condensed shape as this. There are some inaccuracies in it; for instance, the seven-masted schooner "Thomas W. Lawson" is no longer a schooner, having failed to meet the fond hopes of its projectors, but has been stripped and turned into a barge for the oil trade. These small matters do not detract from the value of the book as a whole, but it is not unlikely that the author's views on some of the important topics he discusses, such as ship subsidies, will be considered unreliable by a large class of readers who do not believe in federal aid for a single industry or calling. The author states his views of such controversial topics with moderation, however, and they are accordingly useful to those who wish to obtain in concise form a review of these topics. The first four chapters give an outline of the development and present types of vessels and of the routes and terminals employed by water-borne commerce. The next four chapters describe the ocean freight, passenger, mail and express services, and explain all the procedures which are employed by passengers and shippers; in their relations with ship-owners this class of information has probably never been given before in such detail. In the ninth chapter the author traces the evolution of ocean transportation from the methods of the merchant traders of the eighteenth century down to the formation of the International Mercantile Marine Co. In this branch of transportation the same influences have been at work as in railway transportation, and an interesting analysis of them is given in the next three chapters on monopoly and competition, traffic agreements and pools, and combinations of railway and ocean carriers. In the thirteenth chapter the author discusses the subject of ocean fares and rates, and gives an explanation of the methods of securing business for tramp ships which is among the most interesting things in the book. The following nine chapters are on the relations of the Government to ocean commerce, and contain a large amount of information which is valuable for reference. The book closes with six chapters on canal, river and lake transportation, American conditions being referred to almost entirely. The author is not a ship canal enthusiast, who aspires to improve each little brook in the country so as to furnish flotation for the "Kaiser Wilhelm," nor does he see much use at present in spending large sums on deepening the Mississippi. His views are those of most people who have studied both railway and canal transportation and are stated clearly and moderately. (New York, D. Appleton & Co., $1.50.)

A small handbook on "Mechanical Draft" has been written by Mr. J. H. Kinealy for the use of engineers and draftsmen who have to design power plants. In the preface he states that all the tables in the book have been calculated expressly for it, with the exception of those taken from his volume on centrifugal fans. In addition he states that the formulas and the method of treatment are new, giving the results of his experience and study. The first chapter is a general discussion of the relative advantages and drawbacks of mechanical and chimney draft, arranged so as to bring out comparisons regarding liability to derangement, first cost, depreciation and repairs, running expenses, economy in operation and future extensions. There is also considerable information regarding the usefulness of mechanical draft in burning low-grade coal and on the combination of economizers and mechanical draft equipment. In the second chapter the design and uses of forced draft plants are explained and its advantages and disadvantages are pointed out, while in the next chapter induced draft is taken up in the same way. The fourth chapter is an explanation of the author's methods of determining the amount of air needed by a boiler plant using different kinds of coal and furnishing steam at different pressures. In the next chapter the author first discusses the relation of draft to the rate of combustion and reviews data furnished by a number of previous authors, and then takes up the resistances due to the grate and the economizer. In the sixth chapter the selection of the size of economizer for a given set of conditions is explained. The remaining chapters are on the general features of fans and the design of the separate parts of a mechanical draft installation not already taken up. There is also an appendix containing several tables. (New York, Spon & Chamberlain, $2.00.)

Letters to the Editor.

The Action of Oil on Concrete.

SIR: Replying to the inquiry in your issue of Feb. 9 of H. U. Clotts relative to the action of oil on concrete, it may be said that animal and vegetable oils have an affinity for the alkaline constituents of the concrete, the action being rather slow but resulting in the softening and disintegration of the concrete. In regard to petroleum and the products therefrom, the writer has used concrete for lining the bottom and sides of riveted steel tanks, and has also constructed both oil and water tankage of reinforced concrete, all of which, after years of service, show no indication of action by the oil on the concrete. Concrete which is waterproof, however, is not necessarily oil-proof. Oil will creep through the pores of concrete when water will not.

Yours truly, JOHN LATHROP GRAY.

Bayonne, Feb. 20.

Keeping Records of Field Expenses in Cost-Plus-Percentage Work.

[A few months ago, Mr. George A. Damon, managing engineer of the Arnold Co., read a paper before the Western Society of Engineers on engineering contracting, of which an abstract was printed in this journal on Dec. 1, 1906. A number of inquiries have been received concerning his methods of keeping account of field expenses so as to avoid controversy with the client concerning them, and in order to give an authoritative statement of the matter the following letter has been kindly furnished by Mr. Damon.—EDITOR.]

SIR: In order to understand our position as constructors, you must know of the various ways in which we are prepared to serve a client. Ordinarily our work divides itself into the following divisions:

Preliminary Reports.
Plans and Specifications.
Inspection and Tests.
Construction.
Operation

Our compensation for preliminary reports is either on a per diem basis or at an agreed sum. The next three classes of service are nearly always arranged for on a percentage basis.

We aim to complete our work as consulting engineers on the plans and specifications before making definite arrangements with our client covering the actual construction work. This policy leaves our client perfectly free to carry out the work in accordance with his own wishes. If he turns the construction work over to us on a percentage arrangement it will be because he has been thoroughly satisfied with our services as engineers, and because that under the conditions surrounding his particular piece of work we are more competent to serve him as constructors than would be a multitude of small contractors, or even one general contractor making a lump sum bid. If, however, we are not intrusted with the actual construction work, then an arrangement is made with us to supervise the work in a consulting capacity to determine whether or not the labor and material furnished by the contractor is in accordance with plans and specifications.

If we take charge of the construction work, we at once put into the hands of our client a detailed estimate of the cost of each building and each part of the equipment. We keep our client fully informed with regard to prices, possible purchases and probable deliveries. We make detailed progress reports at regular intervals showing the expenditures and comparing the actual cost of each division of the work with our original estimates. It is our aim to serve our client as if we were one of his most efficient employees in whom he can have complete confidence. We would much prefer to cancel a construction contract at once than have a dissatisfied client, and as a matter of fact, we have never had a misunderstanding with any of our clients. We find that our efforts to be fair, honest, competent and efficient in all our dealings, are appreciated. Our employees are never called upon to practice the slightest deception of any kind.

It will be seen, therefore, that we approach construction work from a different standpoint than we would if we did not make our own plans. To our engineering ability we add our construction experience and seek to serve our client with an organization capable of carrying out his enterprise from first conception to final operation. We make an effort in our work to keep abreast but not too far ahead of the times. We are jealous of our reputation as engineers and are enthusiastic over our ability as constructors to save our client both time and money. Under these circumstances you can understand that we are making a sincere effort to eliminate the word "controversy" from our vocabulary.

Every job has an engineer in charge who is in touch with the entire problem. He calls to his assistance such help as he requires from our entire technical organization, which now contains nearly eighty men.

The salaries of all our engineers are paid out of our percentage fees. On the other hand, the salaries of all superintendents, as well as the expenses of all other labor, are included in the cost statement which is made monthly, and to which we add the percentage which we are to receive for our services as constructors.

Under these circumstances we find the "cost-plus-a-percentage" plan works in a manner thoroughly satisfactory to all concerned, but it is very probable that if the constructor is not also the architect or engineer, that some other form of building agreement could be found better adapted to the case.

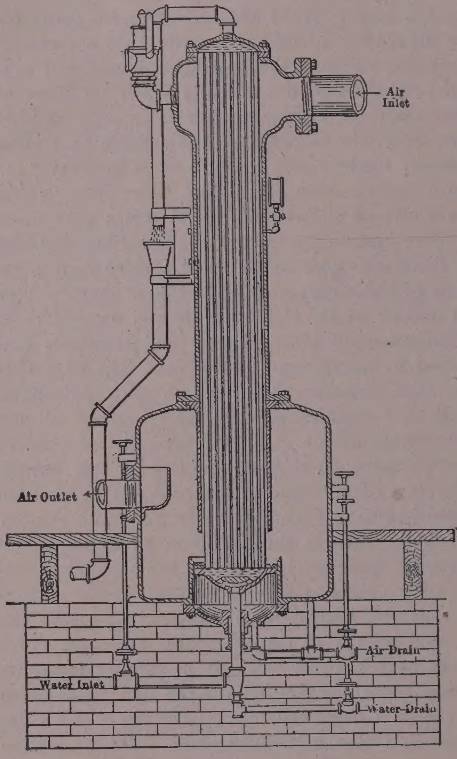
We have tried to give you briefly the general policy upon which our business is growing rather than to describe methods of carrying out details. We are constantly improving our organization details of making records of data, or preparing estimates, of filing progress reports, of compiling records of costs and of carrying out the systems which are essential to doing work of engineer-constructor on a large scale. We are always glad to contribute the results of our experiences from time to time to any effort toward raising the efficiency of technical work.

Very truly yours, George A. Damon.

Chicago, Feb. 14.

How the Intercooler Heats the Cooling Water.

Sir: In my letter entitled "An Impossible Economy in Power Plants," which you kindly printed in your issue of Feb. 9, I regret to have to confess that I said too much, as I sometimes do. It will be remembered that I was criticising your suggestion in a previous issue that there was a possibility of saving some heat by using the heated water from the intercoolers of two-stage air compressors for boiler feed. I said: "Intercoolers upon Ingersoll-Rand compressors will discharge the air at temperatures not more than 10° above that of the circulating water." This statement was true enough, but then I went on with the following assertion or assumption; "If the water as it enters is, say, 60°, it must therefore be discharged below rather than above 70°." Now, there, of course, I was dead wrong.



Vertical Intercooler.

Here comes in what we may call a paradox. Air may enter the intercooler at a pretty high temperature, say 200° to 250°, if compressed to 35 lb. gauge, and, cooled by the water, it may emerge at a temperature not above 70°, and yet the temperature of the cooling water as discharged may be considerably higher than this. I am assured that it has been noticed being discharged much hotter than the air. This will be easily understood when we look at the accompanying cut, which shows one of the latest intercoolers, the vertical intercooler of the Ingersoll-Rand Co. This will be found interesting, and as I believe it has never been shown to the readers of The Engineering Record I offer no apology for thus introducing it.

The trick of it is that the water enters the intercooler at the bottom, is gradually heated as it rises by the air, and then overflows at its hottest temperature from the top of the heater, while the hot air enters at the top, is gradually cooled as it passes downward and emerges at the bottom as cool air. The air at its hottest is where the water is at its hottest while the final cooling of the air is done by the cool entering water.

The construction and the functional relations of the parts of this air cooler, or water heater, are clearly shown in the cut. It is interesting to note how the expansion strains which occur are taken care of. The cooling water fills the thin brass vertical tubes and overflows through a pipe which is led away from the top, the water pressure being only that due to the height of the apparatus. Any sediment which may collect in the lower water chamber is drawn off by the water drain pipe. The upper tube plate into which the brass tubes are expanded is held securely by the dome cover which is bolted over it, but the lower tube head is free to move up or down as the contraction or expansion of the tubes may require. The central water pipe enters the bottom through a stuffing box, and when a slight movement occurs the outside piping connection is always sufficiently yielding.

The air, as was said, enters the intercooler at the top and passes out at the bottom, the final contact with the cooling tubes being where the water is at its lowest temperature. The vertical body of the intercooler is hexagoned and the brass tubes are arranged to fill it completely except for the small and equal spaces which surround each. The total of these spaces is ample for the passage of the air. The air as it enters strikes across the upper ends of the brass tubes and then passes down in intimate contact with all of them without requiring any baffle plates or other devices to divert the current. The hexagonal shape of the body is continued by a petticoat down nearly to the ends of the brass tubes and the air then enters the large settling chamber where it drops its surplus moisture and passes out by the large inverted elbow at the left. It will be seen that this whether regarded as an air cooler or as a water heater is admirably adapted to the simultaneous fulfilment of both functions. The pressure being outside of the brass tubes and they being each of small diameter they are very thin and their heat conductivity is high. The heater has the added practical advantage of being easily taken apart for cleaning or repair, and although it is vertical not much height is required above it for lifting.

Notwithstanding the efficiency of the intercooler and its return of the cooling water at a considerably higher temperature the thermic value of the water for boiler feeding cannot be high.

Yours truly, Frank Richards.

The Cause of Priming in a 15-h.-p. vertical boiler has been investigated by Mr. D. S. Jacobus of the engineering staff of the Babcock & Wilcox Co. The boiler had a water casing around a circular grate and vertical tubes leading directly upwards from the combustion chamber to the chimney above the upper tube plate. It was found that when retarders were placed in the tubes the temperature was evenly distributed over them all, whereas without retarders the temperature of the gases from the tubes nearest the center was much higher than that of those in the outer circumferential rows. Working normally, without retarders, the steam was dry for ordinary rates of combustion, and was slightly superheated when the boiler was forced. When the retarders were used severe priming took place, showing that the conditions of circulation were interfered with, none of the tubes being cool enough to permit them to act as down-comers. The whole of the water in the boiler was thus periodically thrown into a foaming condition, and part was ejected with the steam from the boiler.